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How Harvard 'Capitulated'

INTERNATIONAL
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ARTIFICIAL INTELLIGENCE VS. CANCER

ISSN 2052-1081

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FEATURES

IN SEARCH OF A CURE
Cancer research is costly, to be sure. But in the long haul, it is a bargain.

COVER CREDIT
Janulla/Getty

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Cancer in The Crosshairs

Precision medicine is crushing once-untreatable cancers. Can more patients benefit? Plus: Bargain research, AI diagnosis, cancer by the numbers and cracking the cancer code.

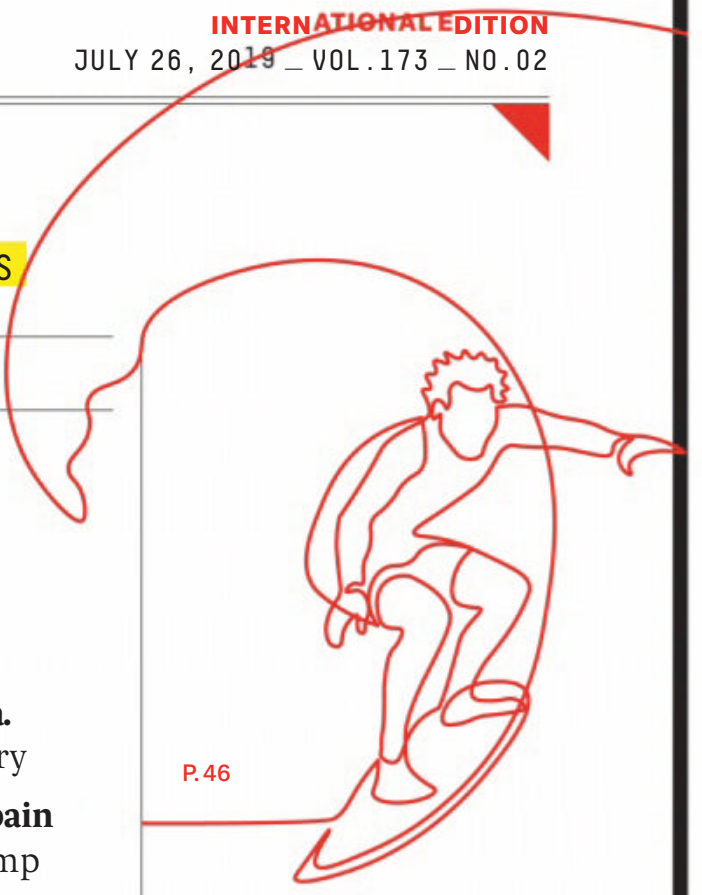
Newsweek

INTERNATIONAL EDITION
JULY 26, 2019 _ VOL.173 _ NO.02

DEPARTMENTS

DID HARVARD CAVE?
In an exclusive interview with *Newsweek*'s Roger Parloff, Ronald Sullivan tells why he and his wife were unfairly fired as faculty deans—under pressure from student protesters.

In Focus



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Periscope

Culture

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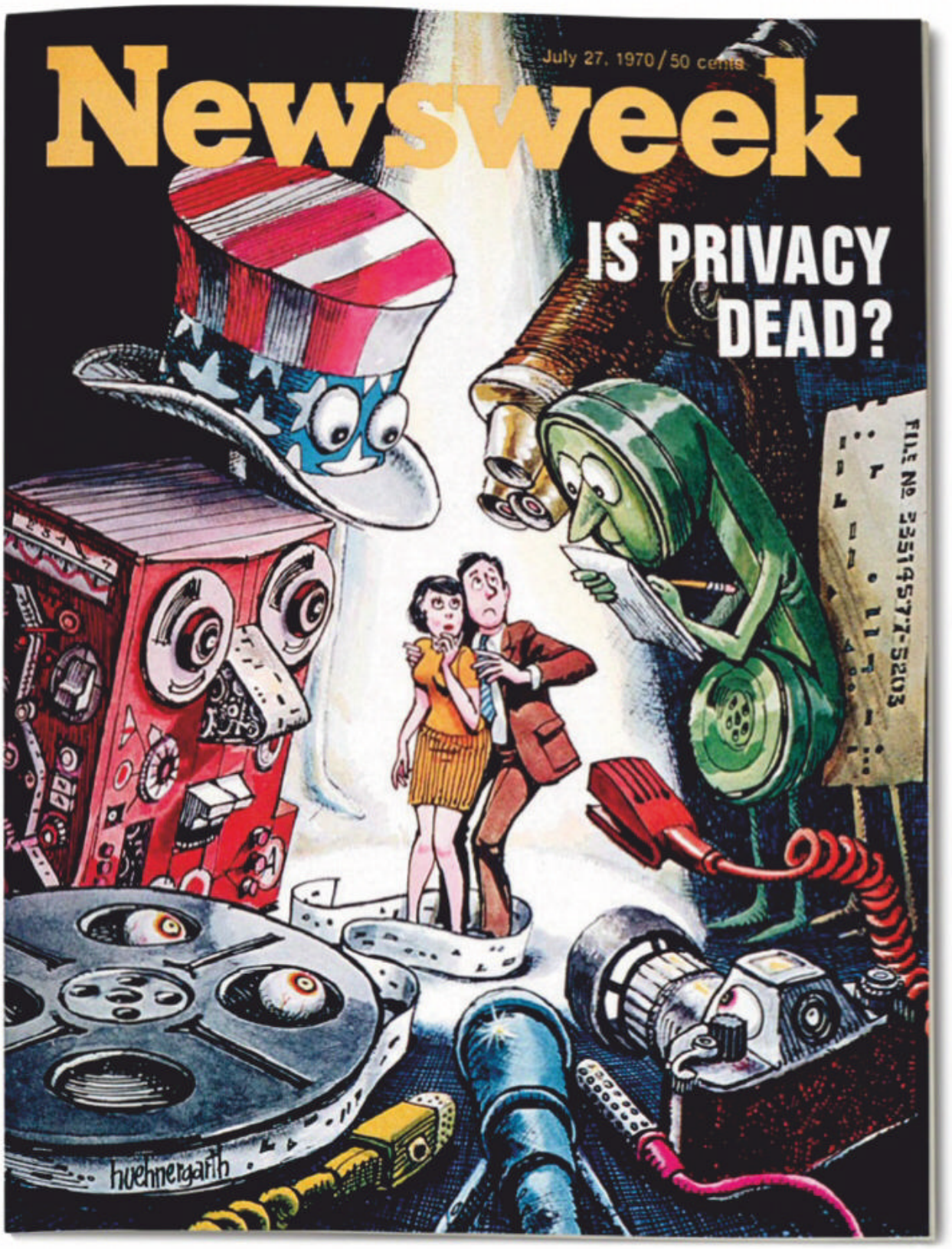
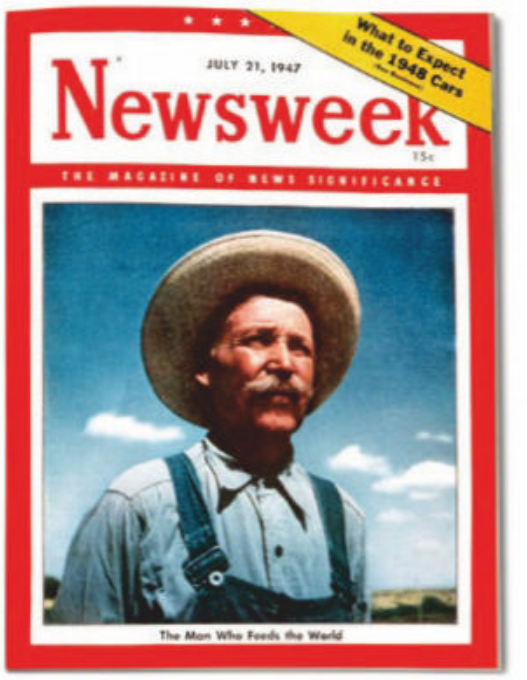
The Archives

1970 "Privacy, always held [as] an American birthright, is being nibbled away steadily," claimed *Newsweek,* as the rise of technology ushered in "all the debatable charms of wire-taps, in-depth questionnaires and other up-to-date invaders of the body private." All this left Americans wondering if "we may end up with 1984 long before we actually get there." Nearly half a century later in the electronic age of social media, oversharing and data breaches, it begs the question if there's anything left to be nibbled away.





1947

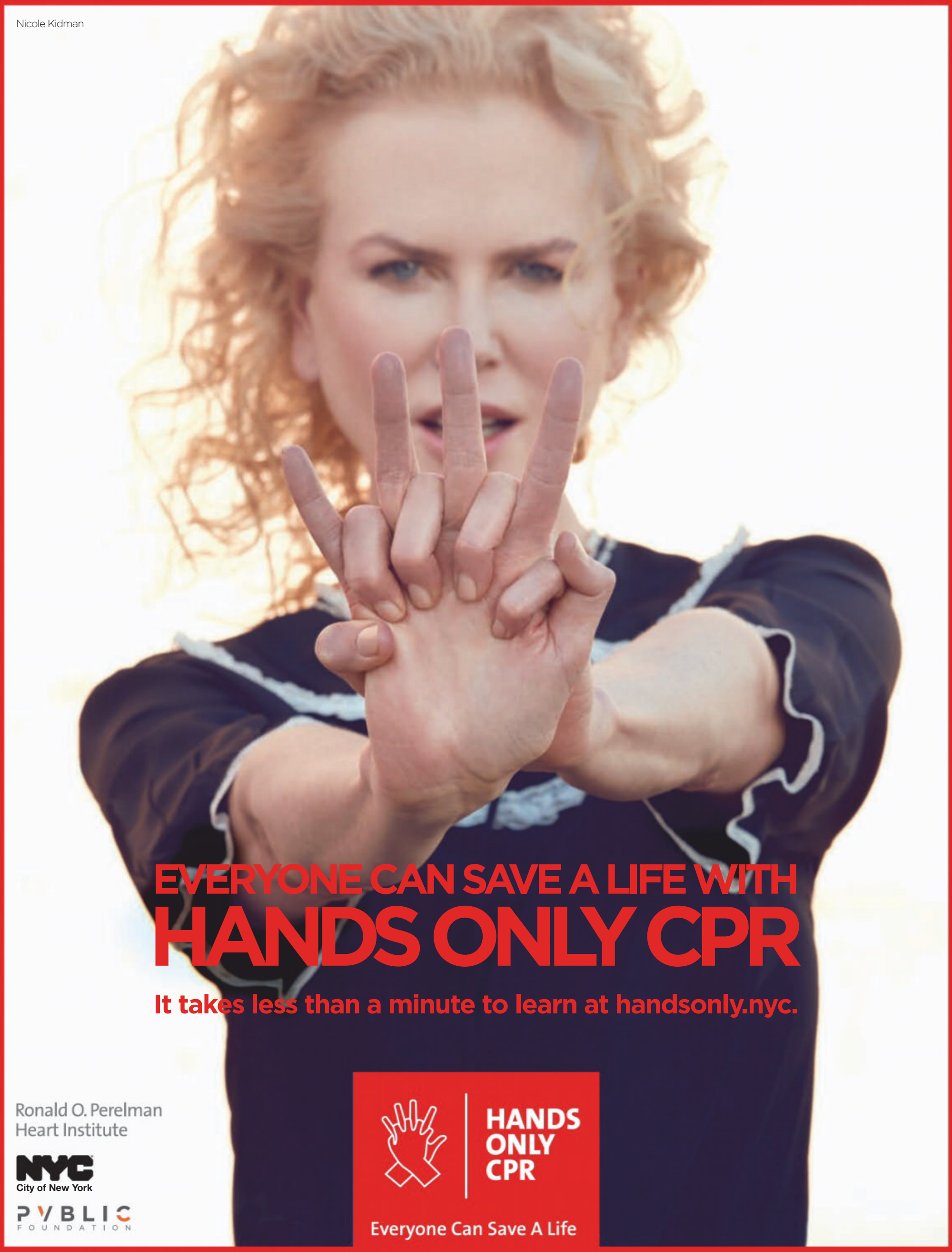
From the Missouri River to the Nevada deserts, where wheat chaff covered clothes and filled lungs, the clatter of giant combines echoed across 150,000 bustling farms 14 hours a day. "It's harvest time in the wheat belt," wrote *Newsweek*, and "now more than ever, America is the world's bread basket."

1962

"In the time it takes to read this story," *Newsweek* reported, "3,600 babies will be born around the world." That boom threatened to impoverish the world, the magazine warned, adding "by the year 2000 the world could have some 6.2 billion people" (Now we're pushing 8 billion). A health official said, "The world has cancer and that cancer cell is us."

LEFT: HUEHNERGARTH; BOTTOM RIGHT: ELIZABETH WILCOX

Nicole Kidman



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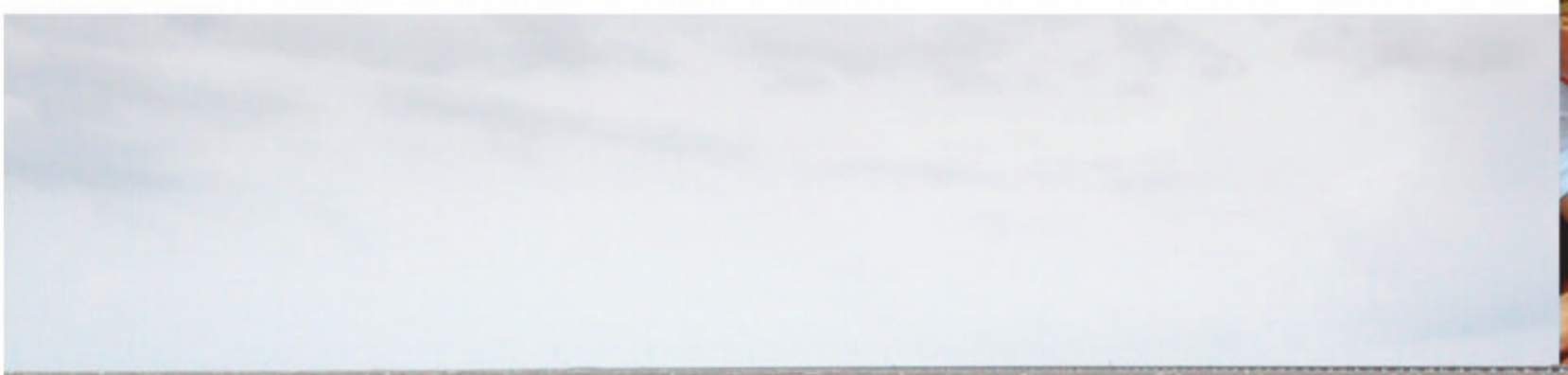
DOKUCHAYEVSK, UKRAINE

No Peace

A Ukrainian soldier engages with Russian-backed separatists in the Donetsk region on July 13 as the five-year-old war in the east of the country drags on. Despite the Minsk Protocol, which attempted to effect a limited ceasefire, some 13,000 people have been killed and as many as 30,000 wounded since the conflict began.

→ ANATOLII STEPANOV

ANATOLII STEPANOV/AFP/GETTY



CLOCKWISE FROM BOTTOM LEFT: SETH HERALD/AFP/GETTY; KIM WON JIN/AFP/GETTY; ANDER GILLENEA/AFP/GETTY

PYONGYANG, NORTH KOREA

Cult of Personality

North Koreans bow before twin statues of Kim Il Sung (left) and Kim Jong Il, grandfather and father respectively of the country's current dictator Kim Jong Un. The ceremony, at Pyongyang's Grand Monument on Mansu Hill, was held to mark the 25th anniversary of Kim Il Sung's death.

→ KIM WON JIN

MANDEVILLE, LOUISIANA

Waterlogged

A woman walks her bike near Lake Pontchartrain after Tropical Storm Barry came ashore on July 14. While the first hurricane of the Atlantic season was downgraded to a tropical storm after making landfall, it nevertheless caused widespread flooding and power outages and threatened additional flash floods.

→ SETH HERALD

PAMPLONA, SPAIN

A Flying Leap

A heifer jumps over a pile of thrillseekers as part of this year's San Fermin festival. After the daily running of the bulls through the streets of the city during the nine-day celebration, heifers are turned loose in Pamplona's bullring. Though younger and smaller than their higher profile male counterparts, the fast, strong and sharp-horned female animals are just as dangerous.

→ ANDER GILLENEA

BLINDSIDED BY WEINSTEIN

"I certainly did not anticipate the reaction to the representation."

What's even cooler than a NYC ticker-tape parade? » P.16

THE NEWSWEEK INTERVIEW

How Harvard 'Capitulated'

Exclusive: Ron Sullivan on defending Harvey Weinstein and the campus culture that cost him his job

HARVARD COLLEGE DID NOT RENEW RONALD S. Sullivan Jr., and his wife's contracts as faculty deans of Winthrop House, one of the school's 12 residential communities—the culmination of a series of campus protests. The turmoil was unleashed after the New York Post *reported in January that Sullivan—a clinical professor at Harvard Law School, the head of its Criminal Justice Institute and a nationally prominent criminal defense attorney—would be joining film producer Harvey Weinstein's legal defense team against a five-count indictment in New York State Supreme Court alleging rape and predatory sexual abuse.*

Some students protested that his role on Weinstein's team was inconsistent with Sullivan's duties as faculty dean, and even that they felt unsafe with a dean who was aiding such a person.

In a Newsweek *exclusive, Sullivan gave his first interview since his ouster to contributor Roger Parloff; he defended taking the case and accused Rakesh Khurana, Dean of Harvard College, of "cower[ing]" and "capitulating" to the "loudest voices in the room."*

Sullivan, 52, grew up in Gary, Indiana, where he attended public schools that were "100 percent" African American, he says. He graduated from Morehouse College in Atlanta in 1989 and Harvard Law School in 1994. Sullivan met his wife, Stephanie Robinson, when they were both students at Harvard Law School. She is also now an instructor there. She was formerly chief counsel to Senator Ted Kennedy; CEO of the Jamestown Project, a democracy-related think tank; and a national radio show host.

While serving as Winthrop House's faculty dean, Ron Sullivan handled many high-profile cases, though most were the kind that were apt to be seen as popular causes on a college campus. He represented the family of Michael Brown, who was fatally shot by a police officer in Ferguson, Missouri, in 2014. (The family won a $1.5 million wrongful death settlement in 2017.) In 2014, Sullivan designed and implemented the conviction review unit at the Brooklyn District Attorney's Office, which has since won release for more than 20 wrongfully convicted inmates, some of whom had served decades in prison.

In 2009, Sullivan and Robinson were named House Masters at Winthrop House. (Harvard changed the "House Master" title to "Faculty Dean" in 2016, after complaints about the term's associations with slavery.)

On May 13, a few days after Sullivan was told that his faculty dean contract would not be renewed, Sullivan withdrew from the Weinstein representation. He cited a judge's decision to postpone the start of the Weinstein trial from June until September, when it would conflict with Sullivan's teaching schedule.

BY

ROGER PARLOFF

@rparloff

This has been edited for space; the full text is available on newsweek.com

FIFA/GETTY

Photograph by CHRISTOPHER LANE

NEWSWEEK: How did you come to join the criminal defense team representing Harvey Weinstein?

SULLIVAN: A colleague at the law school emailed me and asked whether I'd have any moral objection to representing Harvey Weinstein. When I got the email, I actually thought this was an ethics question—something she was posing to her class. I wrote back: Of course not. Every citizen has a right to a defense no matter how heinous the crime is or how unpopular the client. Then a few minutes later she wrote back and said, "He'd like to talk to you."

So quickly I figured out this was not a law professor hypothetical. This was an on-the-ground reality. So I told my colleague that it was fine, and to give him my cellphone number, and we talked, and here we are.

What was your thought process as far as your position at Winthrop House and the potential reaction of the students?

I must say that I certainly did not anticipate the reaction to the representation. And I should say "the reaction *at the college* to the representation." The law school was fine. [Fifty-two current and former members of the Harvard Law School faculty signed a petition supporting Sullivan.]

But I did not anticipate the reaction of the college, largely because of my history of these types of representations. Just the semester before, I was the lead prosecutor in the case against Eric Greitens, the then-governor of Missouri. And that case was all about an alleged sexual assault in the context of an invasion of privacy. So it's not as though I hadn't done a high-profile sexual assault case. But this one [the Weinstein case], appears to have been on the "wrong side" of the issue.

You had also done some potentially unpopular cases while at Winthrop House?

Oh, absolutely. I represented [former New England Patriot] Aaron Hernandez in a double murder case. In which I won an acquittal. He was an extraordinarily unpopular figure in Boston at that time. He had already been convicted of one murder when I represented him in the double murder... There was no backlash or pushback for that representation at all. Indeed, students came to court to watch it. And, an interesting aside—later on, after I started representing Weinstein, a group of students asked if Winthrop House could rent a bus and take them to watch the Weinstein trial. Just making the point that there were still wide swaths of the student population that reacted the same way they had with the Hernandez case—or the terrorism case I tried. They wanted to see how the court system worked in action.

What was the terrorism case?

I represented the family of Usaamah Rahim. He was an alleged terrorist who was shot by Boston police and the FBI as they were attempting to execute an arrest warrant. And I represented his family on a claim of wrongful death.

If students feel they've been the victim of sexual harassment or misconduct, they would take that up with you or your wife as faculty deans?

In theory, they certainly could. The norm in all of the houses is that students would talk to either their tutor—the tutor is a residential graduate student who lives in the house—or to the CARE tutor [for Consent Advocates and Relationship Educators], which is the sexual assault tutor. They could also report to the resident dean, who functionally is the assistant dean.

In 10 years there's never been a whisper that I've been anything but attentive to their needs... Even during this controversy there was a Winthrop student, a young woman, who I was representing in a Title IX proceeding, who accused someone of sexual assault. Now obviously I couldn't talk about it, because it was confidential. But the notion that I could not do both was demonstrably false.

Did she express any discomfort to you?

Not at all.

Was the Weinstein case a pretty lucrative assignment?

I don't discuss fees with respect to any of my clients. But Weinstein was not a *pro bono* case.

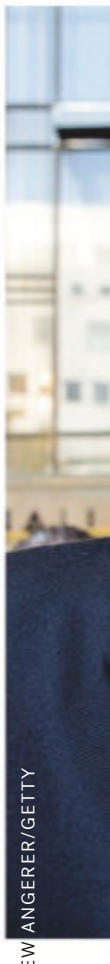
Are there people you would not represent?

Yes. In theory, I am sure, we could come to a scenario where I would say, no, I would not represent this person. But I do not have categories of individuals that I say I would refuse to represent.

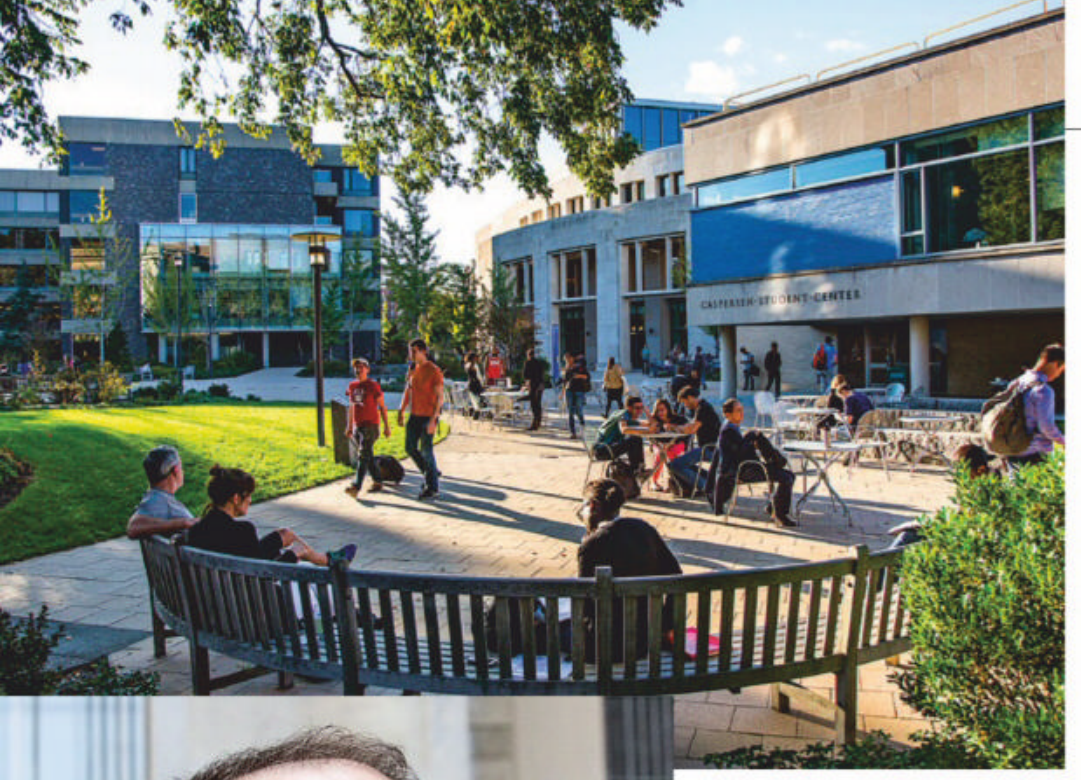
How can it be noble to represent guilty people?

It is noble to represent the guilty because that keeps our system honest. Representing the guilty ensures that the due process rights that you and I

"Students absolutely have the right to protest...but the response from the adults in the room was extraordinarily disheartening."



CLOCKWISE FROM TOP: BROOKS KRAFT LLC/CORBIS/GETTY; JIM ROGASH/GETTY; DREW ANGERER/GETTY



DEFENDING THE BAD GUYS
Clockwise from below: The late Aaron Hernandez of the New England Patriots, who Sullivan represented in a double-murder case; Harvey Weinstein; and the campus of the Harvard Law School.

enjoy are actualized and realized. One very brief example: from all historical accounts, Ernesto Miranda was not a particularly nice individual. [Miranda had been convicted of kidnapping and rape before his convictions were overturned by the Supreme Court for not having been warned of his rights before interrogation while in custody.] But because of lawyers representing him *pro bono*, we now have one of the most central protections in our constitutional criminal law: the Miranda warnings. This is why we do this work.

What were the first negative reactions by college students that you became aware of?

People began to send me posts from social media from Harvard College students—mainly outside Winthrop House. That's when I became aware that people objected to it.

I convened a meeting of the house tutors, because I wanted to get a sense of what the mood at the house was. And I instructed the tutors to have what we call entryway meetings...and to report back whether people had concerns. And the third thing that I did was have open office hours—two of them—where I invited students to come in and talk about it.

One [House] tutor created a category of responsibility for the faculty dean that she called "pastoral," and said there were concerns about my "pastoral duties" as faculty dean. To which I responded that that's the beauty of a university setting—that we can use this as a teaching moment. To talk about competing values and how we resolve tensions.

To the degree that there's a pastoral role, I served it well for 10 years and could have served it well for the next 10 years. With a more thoughtful response from the Harvard Dean's office, we as a community could have and would have worked through this.

Then there's a demonstration; a sit-in at the Winthrop House dining hall; graffiti is spray painted on house walls; and some students said they felt "unsafe."

The paper reported 50 people. There were about 30 students at the protest. The rest were reporters and administrators and so forth. The sit-in—once again, small number of students. And a small group of students committed the vandalism at Winthrop House. So the notion that this was widespread, and there were hundreds of students protesting, is factually incorrect. There was a small but vocal minority of students.

There was a petition for your removal that gathered more than 300 signatures.

Right, there was a petition. And then a group organized itself as Students for Sullivan and did a petition that had 1,100 signatures.

Now, the student newspaper also had editors on it who led the protests. So they would print that there's a petition with 300 students on there, but it was not newsworthy to point out that there was a competing one with 1,100 names on it. [The president of the *Harvard Crimson*, Kristine Guillaume, referred *Newsweek* to a statement she had published: "Our reporters and edi-

tors have done their due diligence in reporting and providing balanced coverage on this subject and all others."]

What about the students who said they felt unsafe and didn't want to receive diplomas from you?
So, the feeling of being unsafe: I certainly cannot dispute how some people feel. But I strongly believe that it's the duty of an educator to ensure policy is not made as a function merely of subjective feeling. Rather, the job of the educator is to help students determine whether their feelings are rational. For example, a Christian student may feel unsafe with a Muslim head of house. I would argue that a good educator would explore those feelings and help educate the student in a way where the student can exist in a diverse, heterogeneous environment, and not run the Muslim head of house out. One can think of all sorts of examples. Does a Christian student feel unsafe with an atheist head of house? Does a right-to-life student feel unsafe with a head of house who's a physician who has done abortions? You can think of a lot of examples where a student may subjectively feel unsafe. But that in and of itself is simply not a good criterion to make university policy.

What was the first you heard from Dean Khurana after your Weinstein representation was disclosed?
I don't recall. Within a week or so. Our initial conversations were quite positive. He told me he wanted to work with me to ensure that we can work through whatever was going on at Winthrop House. He shared with me that socialist students had told him that they felt unsafe with

STANDING HIS GROUND "The job of an educator is to help students determine whether their feelings are rational."

Photograph by CHRISTOPHER LANE

him because of his business school connections. He's a professor at the Harvard Business School. So this phenomenon of students feeling unsafe is not simply limited to the matter I was going through, but, rather, it's a broader phenomenon.

When did things seem to change with him?

As the student newspaper began writing successive, negative articles, Dean Khurana capitulated to that mood and became quite adversarial. [The change] first manifested itself in an article I read in the *Crimson* where they quoted Dean Khurana who shockingly mischaracterized the friendly meetings that we had about the issue. He was quoted as saying that he had reminded me of my duties as faculty dean, which was just demonstrably a lie. So that's when I knew that Dean Khurana was beginning to cower to the loudest voices in the room.

On February 25, Dean Khurana commences a "survey of the climate." And then on May 10, there's a lengthy *Crimson* article that says 11 current and former tutors had signed a statement saying they felt a "climate of hostility and suspicion" at Winthrop House.

That article was a laughable hit piece. It regarded something that happened in 2016. And the administration knows this, because they know what sparked it, and we had several meetings regarding the issue, and it was resolved in due course. So if I had done something wrong in 2016, the university would have taken action in 2016... [or] in 2017. Or, surely, they would not have reappointed me in 2018... This is brought up as an after-the-fact justification.

Students absolutely have a right to protest, and I will support it to my dying day. That's what students do. And they should do, and they should keep doing it. But the response from the adults in the room was extraordinarily disheartening.

"It is noble to represent the guilty, because that keeps our system honest."

The day after that article, Dean Khurana notifies Winthrop affiliates that your contract will not be renewed. He says in the email: "Over the last few weeks, students and staff have continued to communicate concerns about the climate in Winthrop House.... The concerns expressed have been serious and numerous... I have concluded that the situation in the house is untenable."

That letter was pure make-believe. It's interesting that Harvard never released the climate survey. They never released [it], I submit, because it did not fit their narrative. I am confident that a majority of Winthrop students said they are just fine in Winthrop house.

Did you give the students their diplomas?

I did.

Were there protests?

We allowed students to opt-out. I had a colleague from the law school hand out diplomas to students who opted out. We had 150-plus students graduate Winthrop. There were 30 on the opt-out list who received their diplomas from a different person.

What was really, though, hurtful to me about that, is that the organizers of the opt-out list put people on the list without their knowledge or consent. People came to me right after the graduation ceremony to say: "Will you take a picture with me handing me the diploma? I don't know how my name got on that list. I didn't put it on there."

Do you think race played a role in Harvard's treatment of you?

I have no idea. What I do know is that to my knowledge no master or faculty dean in the history of the institution has been treated as callously as I was. Whether it's because of race, my height, my profession—I don't know. And to be honest, I don't care. I care about the result. And to the degree that I can do anything, I'm going to spend some time to ensure that the university behaves better in the future.

I'm hoping that what comes out of this is a better Harvard. I love Harvard. I'm a faculty member there. I'm an alum. And I'm a strong supporter of the students at Harvard for over a decade now. So I want to help make a better Harvard. A place where people dialog rather than engage in projects of demonization. A place where competing ideas can get sorted out in the marketplace of ideas rather than angry protests dictating policy.

The president of Harvard during the same period responded to protests about fossil fuels by saying that he responds to debate, not demands. I think that is the right sort of attitude. And the college would have done well to have listened to him on that and applied that principle to my situation.

In the end, I have moved past what happened to me. I have an appointment at the Harvard Law School and will continue doing my work again, and I'll be just fine. But I will use this to ensure that this sort of thing doesn't happen to others.

NEWSMAKERS

Talking Points

GIZMODO

"People think they have a level of privacy they don't. Why don't they give me a choice?"

—APPLE COFOUNDER STEVE WOZNIAK, ON DELETING HIS FACEBOOK ACCOUNT LAST YEAR

ZORA

"ONE RACE DOESN'T NEED TO HAVE THE MONOPOLY ON MYTHICAL CREATURES."

—BLOGGER MONIQUE JONES ON CASTING HALLE BAILEY AS ARIEL IN THE REMAKE OF THE LITTLE MERMAID

Halle Bailey

DEADSPIN

"Major League Baseball's turning this game into a joke."

—HOUSTON ASTROS PITCHER JUSTIN VERLANDER, WHO SUSPECTS BASEBALLS ARE BEING "JUICED"

Justin Verlander

abc

"We get to look him in the face today and see him in handcuffs. Finally, that day has come."

—COURTNEY WILD, A VICTIM OF ALLEGED SEX TRAFFICKER JEFFREY EPSTEIN AT HIS ARRAIGNMENT

The Guardian

"I'LL GET THEM OUT ONE WAY OR ANOTHER; THROUGH THE DOOR OR THROUGH THE WINDOW."

—Didier Lombard, one of several former France Telecom execs on trial for "moral harassment" that drove employees to suicide

"IF BUSINESS PEOPLE ARE CONCERNED ABOUT ANYTHING, IT'S THE CLEAR, CLEAR PARTISAN POLITICS THAT'S BECOME VERY WICKED AND VERY MEAN."

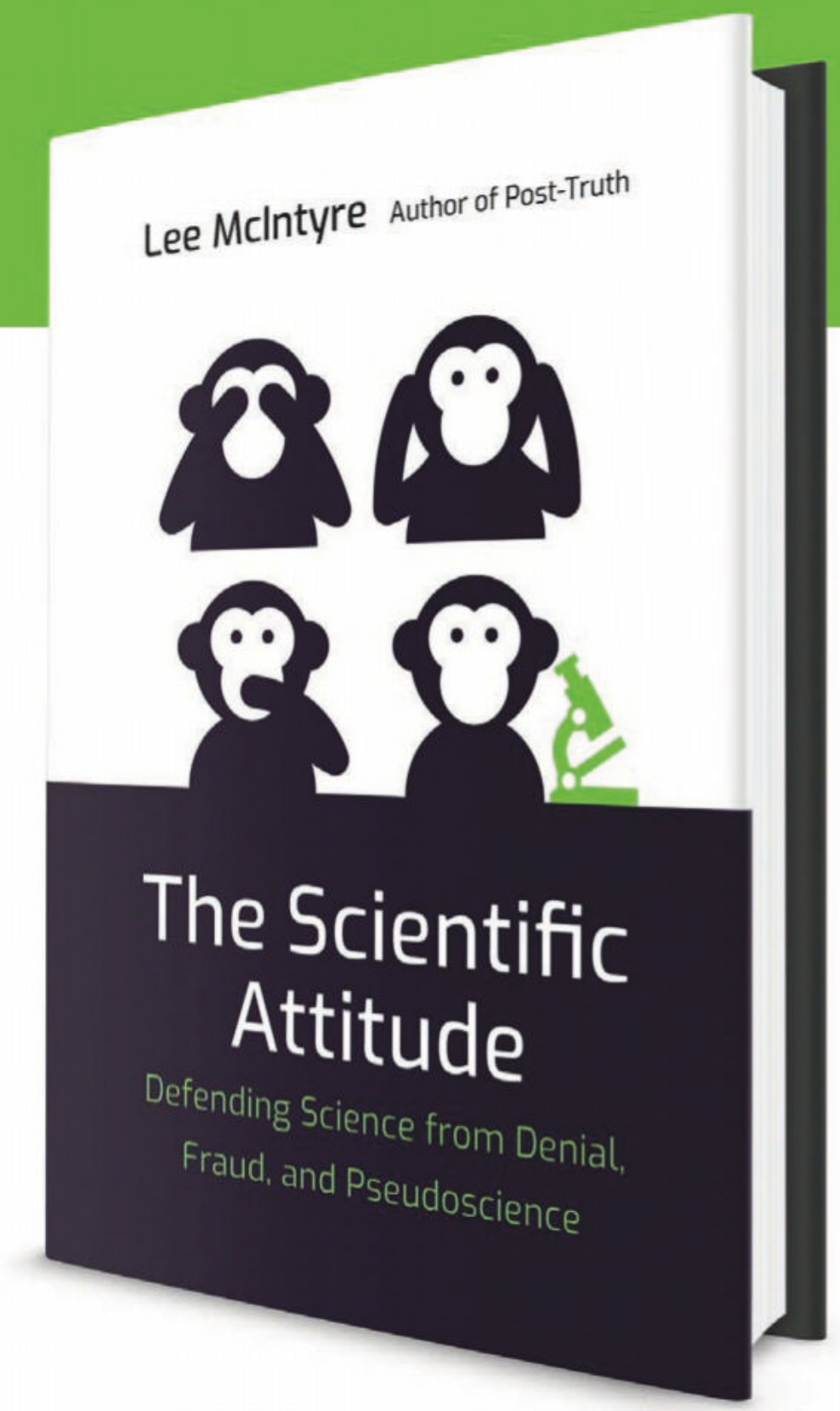
—Robert Johnson, entrepreneur and founder of the BET cable network

Robert Johnson

"Parades are cool. Equal pay is cooler."

—SIGN HELD BY SOCCER DEFENDER CRYSTAL DUNN DURING THE NYC CELEBRATION OF THE U.S. WOMEN'S NATIONAL TEAM'S WORLD CUP VICTORY

FROM LEFT: EMMA MCINTYRE/GETTY; NICK WOSIKA/ICON SPORTSWIRE/GETTY; MICHAEL LOCCISANO/CHURCHILL DOWNS/GETTY



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—Michael Shermer, author of *Why People Believe Weird Things*

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CANCER IN THE CROSSHAIRS

By targeting each patient's unique tumor, PRECISION MEDICINE is crushing once untreatable cancers. But only a fraction of patients currently benefit. Can medicine close the gap?

BY
David H. Freedman

Illustration by STUDIOM1

FROM LEFT: BSIP/UIG/GETTY; SCIENCE PHOTO LIBRARY/GETTY; COURTESY OF OHIO STATE UNIVERSITY COMPREHENSIVE CANCER CENTER

FOR TENS OF THOUSANDS OF PATIENTS, precision medicine is rewriting their cancer stories. Linda Boyed, for example, an energetic 52-year-old occupational therapist, was thrilled to be on vacation with her family in Hawaii, hitting the beaches and taking long walks. But she couldn't shake a constant feeling of fatigue. By the time she returned home, near Columbus, Ohio, her skin had yellowed. Her doctor passed her to an oncologist, who delivered the bad news: Cancer of the bile ducts in her liver had already spread too far for chemotherapy or surgery to do any good. He offered to help keep her comfortable for her final few months.

Boyed's husband refused to accept that prognosis. He found a doctor at Ohio State's cancer center who was running studies of experimental drugs for gastrointestinal cancers. Boyed signed herself up. Genetic tests on her tumors revealed a mutation in a gene called FGFR (short for "fibroblast growth factor receptor"), which was likely spurring the cancer's growth. The doctor gave her an experimental drug, called BGJ398, to inhibit the action of the FGFR mutation. Boyed's symptoms cleared up, the tumors stopped growing, and she regained the weight she had lost.

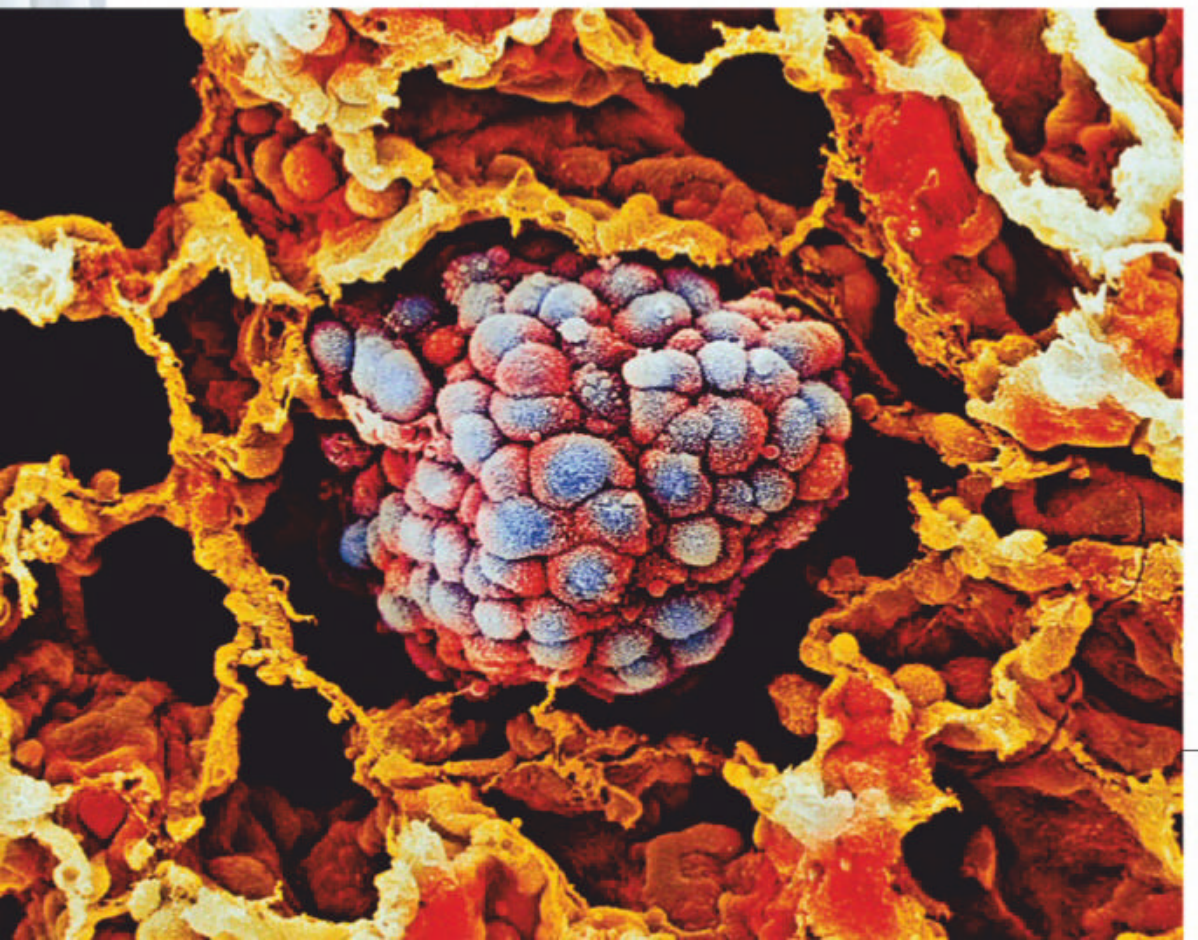
That was three years ago. These days Boyed gets downright bubbly when she tells the story. "I basically lead a normal life now," she says. "I just watched my son graduate from high school. I think I actually did more in the past year than I did before the cancer."

Stories like Boyed's are playing out across the U.S., as new cancer drugs emerge from labs and enter trials.

The days when cancer patients received one-size-fits-all regimens of chemotherapy and radiation may soon be a thing of the past. Instead, doctors are taking a far more nuanced view of what drugs and treatments will work on which patients and on what different kinds of cancers. The idea of this so-called precision medicine, or personalized medicine, is that ultimately doctors will use genetic tests—of both the patient and the cancer tumor—to determine the exact drugs or treatments that have the best chance of working.

Although precision-medicine techniques are now being trained on many diseases, their impact is being felt most strongly in cancer treatment. Researchers are building a growing list of genes and genetic mutations that show up in tumors and matching them to drugs that can stop them. The cancer genes that drugs can target now number in the dozens, and researchers are hot on the trail of hundreds more. For some cancers once considered virtual death sentences, the outlook is already much improved: About half of lung-cancer patients respond well to one the new gene-matched therapies, and in half of those cases, the cancer doesn't come back. FGFR inhibitors, the drug that saved Boyed, have shown promise not only in bile duct cancer but also for some types of bladder, lung, breast and uterine cancers. "We have six trials open now for FGFR inhibitor drugs alone," says Sameek Roychowdhury, the oncologist who saved Boyed's life. "By the end of this year there should be 20."

After decades of fits and starts in the field of cancer research, the progress made in precision



WANTED: SILVER BULLETS The impact of precision medicine is being felt strongly in some types of cancer, where treatments have had high success rates. However, only about one in 10 patients is now eligible for precision medicine treatments. Researchers are trying to expand the number of patients they can treat with targeted therapies; they are on the trail of hundreds of genetic targets. From left to right: a cancer patient; a close-up of cancer cells embedded in lung tissue; James Cancer Hospital at The Ohio State University.

FROM LEFT: COURTESY OF CITY OF NATIONAL HOPE MEDICAL CENTER; TEK IMAGE/SCIENCE PHOTO LIBRARY/GETTY

medicine is welcome news indeed. But make no mistake: There is no "cure." Medicine is not even close to bringing cancer to its knees. For patients diagnosed with advanced cancers—those that have already metastasized, or spread—only one in 10 turn out to have genes currently known to make the cancer susceptible to a new drug. "Our goal is to give 100 percent of patients a new therapy based on genomic testing," says Roychowdhury. "But today we don't know how to provide a special treatment for the results of nine of 10 genomic tests we do."

Most patients don't even get that one-in-ten chance. Many doctors still lack expertise in the area and fail to administer the genetic tests that could open the door to a precision medicine treatment. Expense is also an obstacle: Insurance companies don't reimburse adequately for the tests. For these reasons, only 10 percent of cancer patients undergo genetic testing. Precision medicine is helping, at best, only a few percent of the nearly 2 million people who are diagnosed with cancer in the U.S. each year, and the fraction is much smaller among the 17 million cancer patients worldwide.

To increase the number of patients eligible for treatment, doctors are turning to artificial intelligence for help. Genetic testing is churning out so much data that even an army of Ph.Ds couldn't make sense of it all. Artificial intelligence turns that volume of data from a liability to an advantage. Scientists are now delegating the task of finding the weaknesses in cancer tumors to "deep learning" software that can churn through millions of genetic test results and patient outcomes to find new relationships between tumor genes, cancer growth and specific drugs.

Teasing Out Patterns

TO INCREASE THE ODDS THAT A CANCER PATIENT who walks through their doors is given a treatment option, City of Hope National Medical Center outside of Los Angeles plans within two years to be the first major hospital in the U.S. to do genomic testing on the tumors of every single one of its 9,000 cancer patients a year. "Tumors that look identical under the microscope look vastly different under from a genomic point of view," says Michael Caligiuri, a physician and president of City of Hope National Medical Center outside of Los Angeles. "They need to be treated differently."

As other hospitals follow suit, they will generate a vast volume of data—grist for the AI mill. The

DATA HUNGRY
The explosion of genetic data is a driving force of precision medicine. But because the field is by nature fragmented, researchers searching for new treatments need even more data on cancer patients. To this end, City of Hope National Medical Center outside of Los Angeles plans to do genomic testing on the tumors of all its cancer patients. From left to right: Saul Priceman at City of Hope; a scientist views results of a genetic test on a digital tablet.

Portrait Illustrations by ALEX FINE

WHY COSTLY CANCER RESEARCH IS A BARGAIN

Money spent on avoiding needless care and ensuring patients get the right medication will pay off in the long run

BY Michael Caligiuri

SCIENTISTS DECODED THE DNA OF the first human genome in 2003 after a 13-year process that cost $2.6 billion. Today, we can "sequence" the genome of a cancerous tumor in a day for $1,500 to $3,000.

Decoding the genome may be affordable, but the cost of understanding what it means to cancer treatment has exploded. Piecing together the elements of the genome that really matter in medicine and matching that learning with carefully designed new biopharmaceuticals and new opportunities for older drugs requires a hefty investment in research.

As technologies have evolved, our view of the economics of life-changing genetic tests have become more nuanced. It is important to show not only how these tests can guide the decisions we make with our patients but also how additional testing can bring value to the health care system. If spending money on testing can wring out needless care elsewhere by ensuring the right patients get the right medication, or better still prevent disease, even high-priced tests can be a bargain. As Mary Lasker, the great advocate behind the successful passing of the National Cancer Act in 1971 by former president Richard Nixon, said: "If you think research is expensive, try disease."

What makes next-generation genetic testing so appealing is that it brings us closer to the holy grail of medicine: getting better care without spending more money. There is no worse outcome—for the patient, for the physician, for the health care system—than the delivery of a drug that provides nothing but side effects and expenses.

Demonstrating that we can reach that holy grail is key to making sure that health insurers cover genetic testing as part of a holistic cancer treatment program. That value is now clear for many tests and with many insurers; I expect that trend to continue as testing costs decrease and as data shows benefits to patients. But cost coverage is not universal. We must continue to demand that our insurance companies pay for impactful testing and treatments.

This advocacy won't bear fruit overnight. Doctors have an obligation to ensure coverage of increasingly critical tests. Our research cannot ignore the larger conversation around value. It is vital that our research demonstrates how a given test affects costs as well as outcomes.

Getting more genetic and treatment data from cancer patients, electronic health records and the evolution of artificial intelligence in precision medicine will enable physicians to better predict who will get cancer, how to prevent it and which treatment will provide the best outcome at the earliest stage. That is a great deal, no matter how you cut it.

→ **Michael Caligiuri, M.D.,** *is president of City of Hope National Medical Center and the Deana and Steve Campbell Physician-in-Chief Distinguished Chair in Honor of Alexandra Levine, M.D.*

> "Next-generation genetic testing brings us closer to the holy grail of medicine: getting better care without spending more money."
>
> — MICHAEL CALIGIURI

Scientists are delegating the task of finding the weak

nesses in cancer tumors to "DEEP LEARNING" software.

JOHNNY GREIG/GETTY

LOOKING FOR CLUES
Deep learning algorithms don't really "understand" the biology behind the cancer they're analyzing, but they see patterns that even an army of Ph.Ds would miss. What's needed is lots of data: from MRI, CT and PET scans as well as from genetic testing.

20,000 genes of a typical human genome include three billion DNA nucleotides, or bits of information, any of which can be mutated, repeated or moved in any number of ways to cause cancer. Each of the human body's billions of cells has its own copy of the genome, subject to its own mutations.

But DNA is only part of the picture: Whereas DNA is a blueprint, the real work in our cells is carried out by proteins—complex molecules that control almost everything in our biology. Proteins govern both the growth of a cancer tumor and the work of the immune system in fighting it. There are as many as 6 million basic proteins and variations on them, and researchers are now measuring thousands of them directly in cancer-tissue samples and feeding that information to the deep-learning programs.

"Drugs don't target genes, they target proteins," says David Spetzler, chief scientific officer of Caris Life Sciences in Irving, Texas. "That's where we're seeing the most progress in understanding cancer, and it's what's going to be the most useful information we gather in the next five years." Says Jeffrey Balser, a physician who heads the Vanderbilt University Medical Center: "That's a lot of incredibly deep knowledge coming to the table."

Deep-learning algorithms don't work the way scientists do—they never "understand" the biology behind the cancer they're analyzing. Instead, they digest reams of information from tissue samples of patients that had certain kinds of cancer, and correlate that information with the ultimate fate of those patients—who responded to which treatments and who didn't. It's a kind of hit-or-miss association exercise, but one that's conducted thousands of times, using vast amounts of data. Computers can tease out patterns in the data that a human could never see—linking, say, the presence of the FGFR gene to a particular cancer of the bile duct.

Spetzler's company, for instance, is working to crunch protein-fortified data with deep-learning software. To wring useful insights out of the data from 170,000 cancer patients that Caris has access to, the company enlists hundreds of different deep-learning algorithms. The programs essentially compete with one another to find patterns in the data that indicate which drugs will work best with which patients. "Different algorithms will miss different patients, but together they can do a better job," says Spetzler.

AI is helping provide yet another critical set of clues

RUNNING WITH AI Artificial intelligence plays a big role in cancer research. Caris Life Sciences enlists hundreds of deep-learning algorithms to complete with one another in finding patterns in data on 170,000 patients. Lunit looks for clues in pathology slides that have been digitized. Clockwise from right: David Spetzler, president and chief scientific officer, in Caris's biorepository; a researcher from Lunit feeds biopsy slides into a high-resolution scanner; beforehand, slides are cleaned and inspected.

CLOCKWISE FROM TOP: COURTESY OF CARIS LIFE SCIENCES; JUSSARANG LEE/LUNIT [2]

to how to match patients to new drugs by learning to read slides of tissue samples taken in biopsies. Those slides have always been read under a microscope by pathologists, who come up with a cancer diagnosis based on the cells' appearance. So-called "machine learning" programs are starting to step in. An Israeli company called Nucleai has trained its software with 20 million digitized biopsy slides to recognize cancer, and it already performs with 97 percent accuracy.

Diagnosing cancer is just the start, says Nucleai CEO Avi Veidman. The goal now is to use AI to extract more information from slides than pathologists can—information that can help match patients to new drugs. "Most of the information in that tissue isn't being used when doctors or software are trying to predict the treatments that will work," says Veidman, who spent two decades with Israel's intelligence forces developing AI software to recognize missile bases and terrorist activity in satellite images before turning his attention to cancer three years ago. "AI can analyze the different types of features in the image much more efficiently and find hidden patterns." He notes, for example, that subtle signs of the battle between the patient's cancer cells and immune-system cells can be spotted by the software, and those signs can provide essential clues to whether or not the cancer might be vulnerable to one of several new immunotherapy drugs—that is, drugs that work not by fighting the cancer directly, but by boosting a patient's immune system so it can attack the tumor.

South-Korean firm Lunit has developed AI software that can analyze pathology slides to predict, for example, which patients will respond to a relatively new type of cancer drug called checkpoint inhibitors, which can prevent cancer cells from blocking a patient's immune cells. Lunit claims that the software is 50 percent more accurate than tests that use genetic data alone. "That's going way beyond what human eyes can do," says CEO and physician Beomseok Brandon Suh. "The software is finding patterns that are too complex for people to recognize, but that have biological meaning."

> **We should be able to go to a computer, type in INFORMATION ABOUT A PATIENT's cancer, and up will pop 50 cases around the world that are similar at the molecular level.**

Similar advances are taking place with AI-based systems that are reading X-rays, MRIs and other image data. "There are already algorithms that are as good at reading a mammogram as a highly trained radiologist, or at recognizing skin cancer as a dermatologist," says Chi Young Ok, a pathologist at the MD Anderson

Continued on page 30

ARTIFICIAL INTELLIGENCE AND CRACKING THE CODE TO CANCER

Abraham Heifets of Atomwise is using AI to speed up the development of medications targeted at specific cancer cells

BY Noah Miller

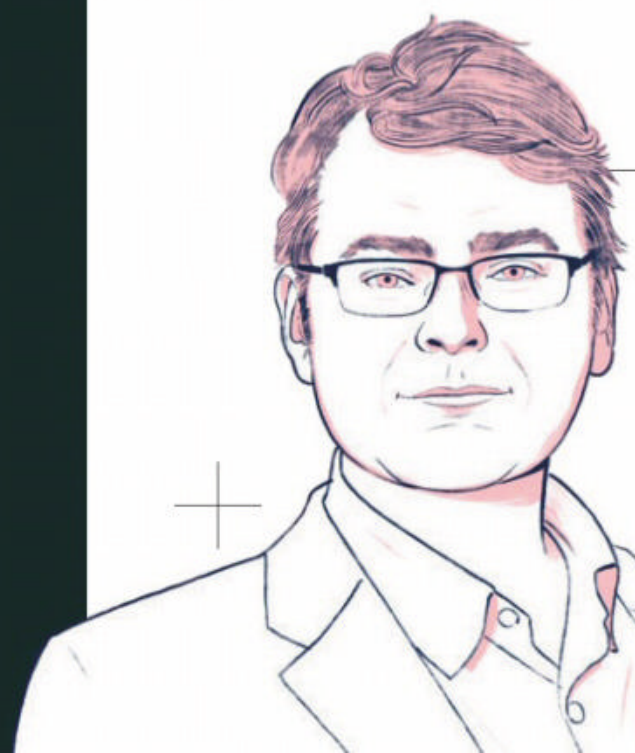
IN ANTICIPATION OF THE 50TH ANNIversary of NASA astronauts landing on the moon, Newsweek *is spotlighting pioneers in science and technology, highlighting their very own moonshots and how they hope to change the world.*

Abraham Heifets is the CEO and cofounder of Atomwise, a biotech company using patented deep learning artificial intelligence technology to predict and discover which drugs will be better, safer and more potent for cancer patients.

Q _ What is your moonshot?
A _ To make novel, better and safer drugs, with the ultimate goal to get medicines into the hands of patients *faster.*

Q _ How do you do that?
A _ We're trying to solve how you modify a cell that's in the runaway disease process, and figure out what's causing a cell to keep growing and dividing. Think of proteins in your body as machines on the assembly line. If the machine governing cell growth and division breaks and goes haywire, then the cell will keep growing and dividing. That's a tumor and how cancer happens. If you see a machine going haywire, you'd want to throw in a monkey wrench so the machine is busy chomping on that instead. Today, it takes about 15 years and several billion dollars to find a new drug. Every day that you don't have good treatment, that's real people, patients, lives and health in the balance.

Q _ How does Atomwise go about searching for the right drugs?
A _ Every other industry uses computers for design. But in pharma, you have to physically make and test every one of those prototypes. If you think about designing a new airplane, you'll simulate a thousand wings before you ever build one. And only after the computer says wing #88 will fly, be fuel efficient and be quiet, and only after you simulate thousands of wings do you then go build the prototype that you take to the wind tunnel for the test flight. Atomwise is about bringing that efficiency and that design into biology and drug discovery.

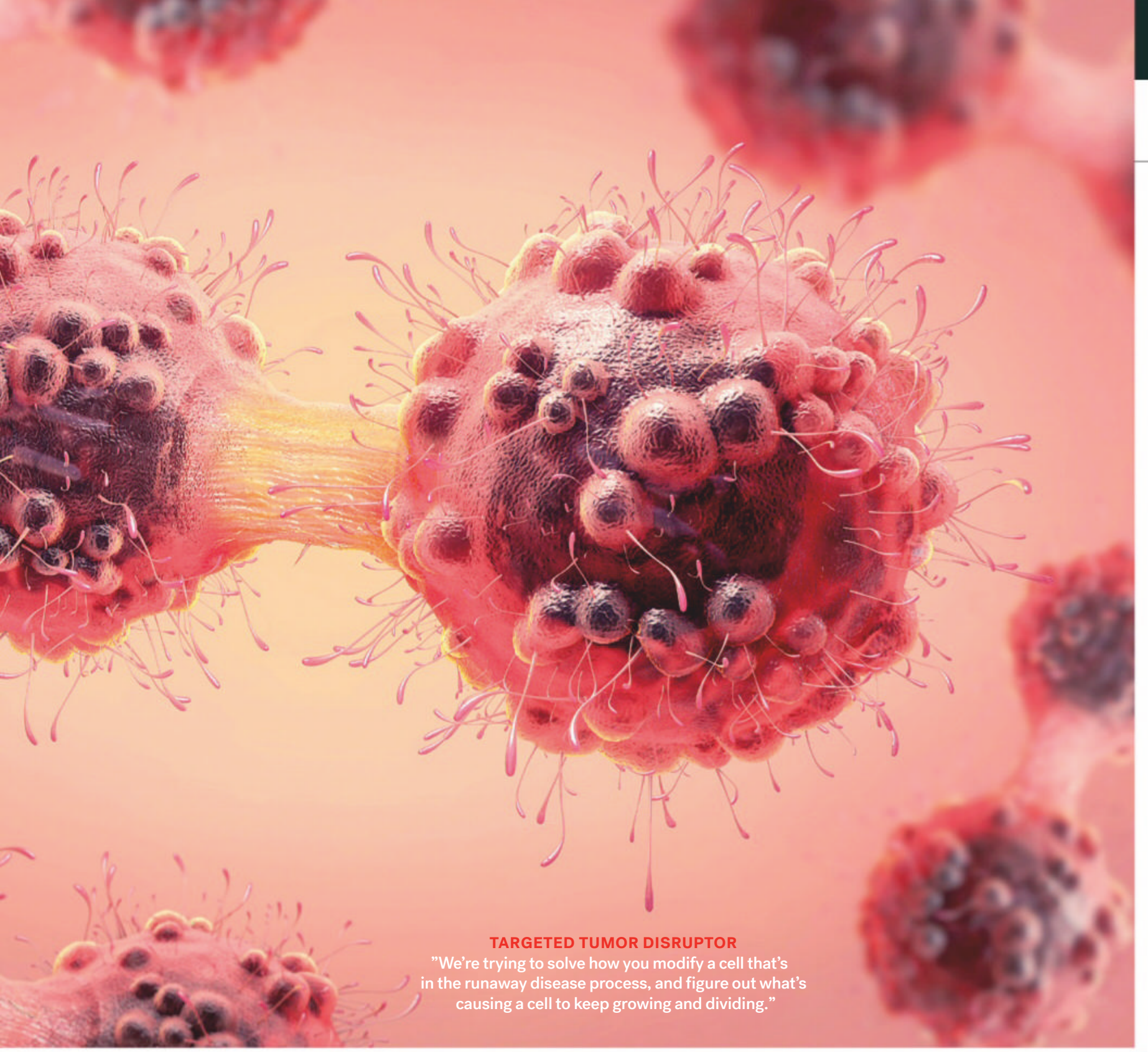


> "Frankly, patients shouldn't have to be patient. It's our job to get medicines to them as fast as possible." — ABRAHAM HEIFETS

CHRISTOPH BURGSTEDT/SCIENCE PHOTO LIBRARY/GETTY

Q _ Using deep learning artificial intelligence?
A _ That's exactly right. My co-founder, Izzy, and I were grad students at the University of Toronto when deep learning and this current era of Artificial Intelligence was being invented. Our computational biology group was on the same hallway as Jeff Hinton's deep learning group. He just won the Nobel Prize of computer science, the Turing Award, for inventing deep learning. We saw pretty early on that the kind of work that was happening for image recognition and speech recognition could be applied to molecular recognition.

Q _ How exactly does AI enable safer, more effective and potent drugs?



TARGETED TUMOR DISRUPTOR
"We're trying to solve how you modify a cell that's in the runaway disease process, and figure out what's causing a cell to keep growing and dividing."

A – Imagine you're a biologist and you've been studying pediatric cancer. You've done tons of experiments and you've determined that if you could just block protein X, that would halt the disease. Rather than trying to kill off every rapidly dividing cell, you want to be able to arrest the disease without harming the healthy cells. Now you need the drug that is effective and safe. AI lets us begin by testing 2,000 times as many molecules as has been tested before. Once you find some sets of molecules that look pretty good, you try to make variations that will improve the molecule. The computer lets you evaluate billions—instead of tens or hundreds—of molecules in one go, which means you're going to find better answers and you're able to discover that winning lottery ticket. Our 10-to-the-10 project is the next step in that, which is running 10 billion molecules against pediatric cancer targets.

Q – Does it feel amazing getting that "winning lottery ticket"?

A – Absolutely. I think everyone goes into this because they want to help people. And frankly, patients shouldn't have to be patient. It's our job to get medicines to them as fast as possible.

Q – What is "success" to you, and are you close to achieving it?

A – Success for everyone in this field is helping patients. A measure of success is that if you look at our large pharma partnerships, you can see they're embracing this new approach; you can see there's trust in Atomwise's AI systems. We recently announced a deal with Eli Lilly for over half a billion dollars. You'll see Bayer and Pfizer. The previous big deal we announced was with Charles River Labs. These industry-standard players have embraced AI approaches.

Q – How do you picture the industry in 20 years if you succeed?

A – The industry is shifting toward AI. We're actually running the biggest application of AI-to-drug discovery in history, and we have over 200 projects in every therapeutic area. So, I think the potential application is huge. About 35% of those projects are in cancers. At the end of the day, our success is patient success.

Cancer Center in Houston. “The progress is astounding.” Eventually those images, too, are likely to help AI systems go beyond diagnosing cancer to spotting hints of the vulnerability of a patient’s unique cancer.

Data Dilemma

DEEP-LEARNING ALGORITHMS LOOK AT MORE DATA and analyze it more thoroughly than machine learning programs do. They are a bit like Seymour, the ravenous plant in Little Shop of Horrors, whose appetite never stopped growing. Although researchers and clinicians now have access to databases that contain information from as many as 250,000 cancer patients, it’s not nearly enough.

Thousands of different mutations in a patient’s genome can shape the development of cancers and determine which treatments are effective. Each cancer cell is a moving target, continually developing new mutations that can help it evade immune cells and survive powerful cancer drugs. Since AI software needs thousands of examples of a particular pattern before it can begin to recognize it, and since a particular pattern of mutations may come up in only a few thousand patients altogether, the software may well need access to the data of millions of patients to make faster progress. “We can make predictions now about how tumors will evolve and what treatments will work, but right now a significant fraction of those predictions are wrong,” says UCLA’s Paul Boutros, a physician who heads up cancer data science for the UCLA Jonsson Comprehensive Cancer Center.

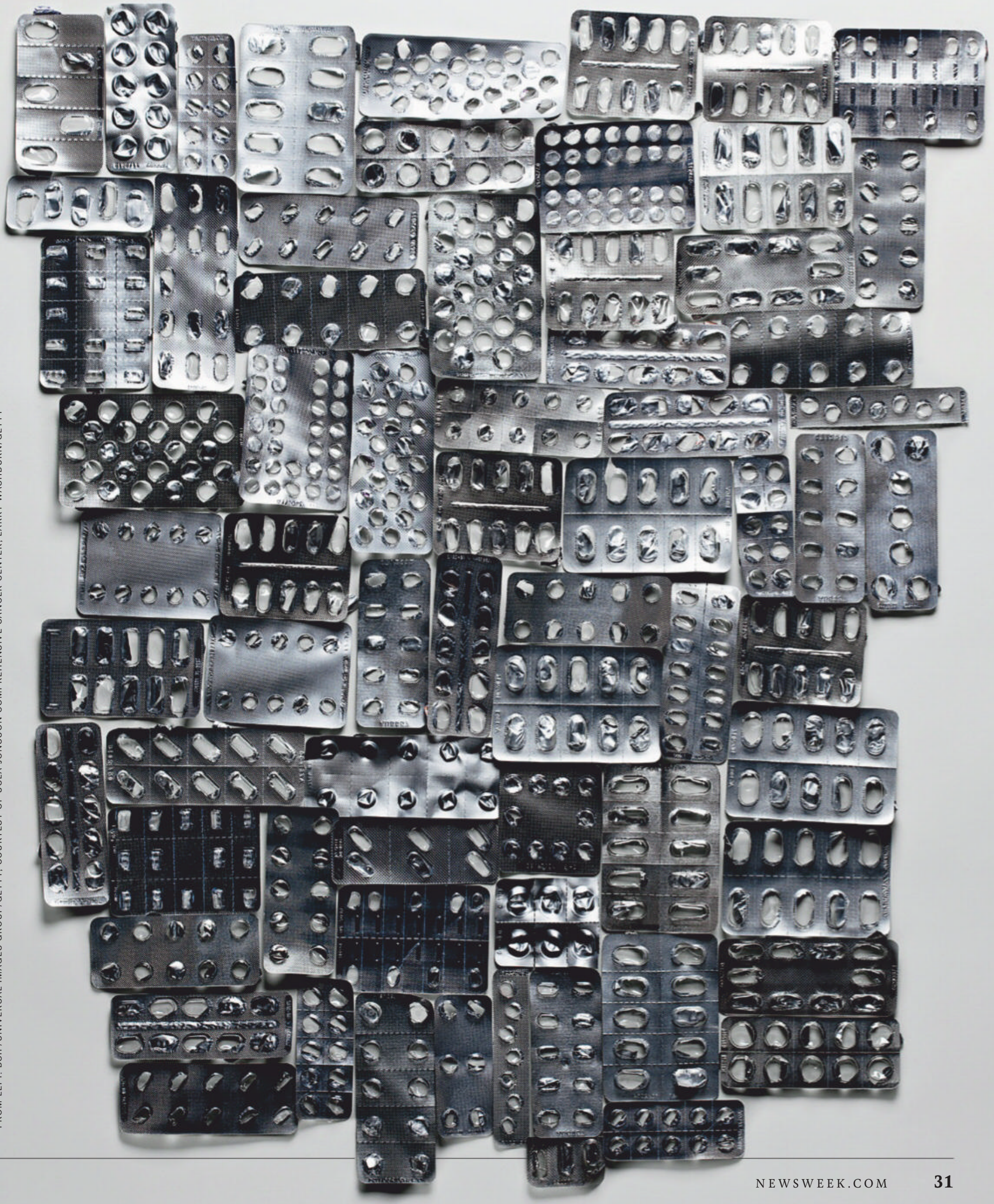
A number of collaborations—with names like the International Cancer Genome Consortium, the Oncology Research Information Exchange Network, and the Actionable Genome Consortium—have sprung up among research centers and hospitals to share patient data. Gathered with patients’ permission and with personally identifiable information stripped out, that data could eventually help researchers reach the needed critical mass of information. “We need to get to the point where all these different data networks are tied together into a network of networks,” says City of Hope’s Caligiuri. Clinicians need access to that data, too, to find patients like the ones they’re treating to see what might work. “We should be able to go to a computer, type in information about a patient’s cancer, and up will pop 50 cases around the world that are similar at the molecular level,” he says.

Easing the Bottleneck

MEDICINE IS OF NO USE IF PATIENTS DON’T HAVE access to it. To get new drugs out faster, researchers are using AI to speed the process of drug development. One of the biggest causes of delay in testing new drugs is recruiting enough patients for a trial. Researchers not only need a group to try the new drug, but another “control” group to get the standard treatment, for purposes of comparison. Even when a new precision drug is promising, it can take

MOVING TARGET
Thousands of genetic mutations come into play in determining what drug will work on a tumor. And the tumors themselves evolve to evade immune cells and survive cancer drugs. For these reasons, many predictions that researchers make about what treatments will work are wrong. Above: Dr. Paul Boutros of UCLA’s Jonsson Comprehensive Cancer Center. Below left: A technician carries out a routine mammogram at a radiology center in France. Right: empty medicine packaging.

“To anyone who has just received a diagnosis of cancer: You need to get a SECOND OPINION from an oncologist who is a specialist in your type of cancer before you start any treatment.



FROM LEFT: BSIP/UNIVERSAL IMAGES GROUP/GETTY; COURTESY OF UCLA JONSSON COMPREHENSIVE CANCER CENTER; LARRY WASHBURN/GETTY

"AI WILL NOT REPLACE ME"

Doctors are turning to artificial intelligence to help diagnose cancer patients

BY David H. Freedman

GENETIC TESTING GETS MOST OF THE attention when it comes to matching cancer patients to specific treatments. But the vast majority of diagnostic information used in selecting a cancer treatment today comes not from those tests, but from under the microscope of the pathologist, who examines tissue biopsies taken during surgery. Stanley Robboy, vice-chair for diagnostic pathology at the Duke University Cancer Center, spoke with Newsweek's David H. Freedman about how artificial intelligence is improving diagnoses—and why some doctors are reluctant to embrace it.

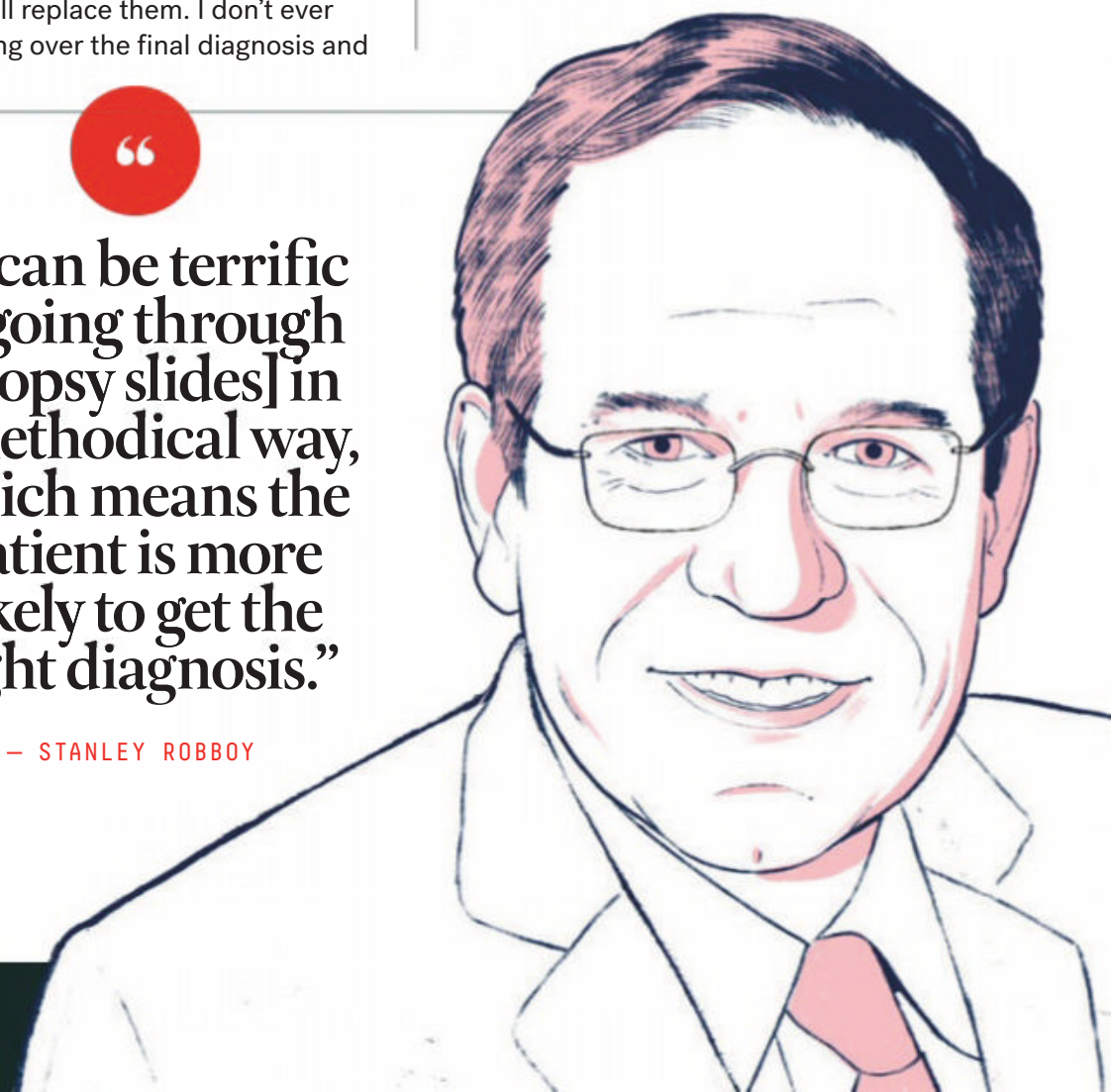
Q _ Is precision medicine changing what pathologists do?
A _ Precision medicine has been advancing for a long time. My father was a medical student when penicillin was discovered in the 1920s. For many years that was a single treatment given for infection, regardless of what the infectious organism was. By the time I was in medical school in the 1960s we had specific antibiotics for specific organisms. For many decades different cancers were treated with the same drugs. Now we can look at the individual genetic pathways of a patient's tumor, and in the lab we can measure the different unique features of a cancer, so that we can often specify drugs that target that cancer's individual mechanisms. Twenty-five years from now we'll be at a whole new, deeper level of diagnostics that goes beyond genetics with new pathology tests that point to new types of drugs we can't imagine yet.

Q _ How is AI helping?
A _ Typically in a cancer case I'll have to look at 30 to 40 lymph nodes to tell if the cancer has spread. Finding one or two cells can make a real difference in a patient's prognosis. A single lymph node has about 300,000 cells and I have go through each slide trying to figure out if a single cancerous cell is hiding in there. It's like looking for the one gray stone among 300,000 white stones on a beach. AI can be terrific at finding that one stone by going through the image in a methodical way, which means the patient is more likely to get the right diagnosis.

Q _ Do some pathologists resist AI?
A _ The issue of trust is a difficult one with AI. It's true, there have been a lot of naysayers, and people who worry that AI will replace them. I don't ever see turning over the final diagnosis and decision-making to a system. These breakthrough tools will help me, not replace me. They'll relieve me of some of the most tedious, time-consuming work, freeing me up to focus on the more complex tasks. They'll look at more of the slide in more detail than I can. And they can give me a second opinion, maybe saving me from making a catastrophic mistake. But they'll never replace my thinking. You can give an airline pilot great auto-pilot technology that will make the pilot's job much easier, but there will always be a need for a Sully [retired American Airlines pilot Chesley Sullenberger] who can use judgment to take over from the system and land a plane on the Hudson. There's no AI system that can replace that judgment.

Q _ What about the impact of AI on the research side?
A _ In my father's day an individual physician would do the work that helped determine whether or not a drug worked for certain patients. Ten years ago, three of us would team up to do that work. Today there might be 20 or even 40 people working together on a problem like that. In the future, an AI system will be a critical member of that team, too. N

> "AI can be terrific at going through [biopsy slides] in a methodical way, which means the patient is more likely to get the right diagnosis."
>
> — STANLEY ROBBOY



INSURANCE GAP Many doctors believe that all cancer patients should routinely receive genetic testing. Many cancer centers don't do so in part because health insurance companies frequently balk at paying for the tests, which can cost $10,000. Even when coverage is provided, getting reimbursed can be an arduous process. Right: Dr. Sameek Roychowdhury at The James at Martha Morehouse Outpatient Care of The Ohio State University

COURTESY OF OHIO STATE UNIVERSITY COMPREHENSIVE CANCER CENTER

years to run the trials that demonstrate the drug actually works for an identifiable group of patients.

To speed things along, researchers are starting to use high-powered statistics and computer models to avoid having to recruit a control group at all. Instead, they use a mashup of data from past studies to predict how a real control group would fare. "The results you get from a synthetic control arm are as reliable as if you had actually enrolled control-group patients in the trial with the same physicians and protocols," says Glen de Vries, president of Medidata Solutions, which has designed the statistical tools.

That won't be enough to ease the trial bottleneck for clinicians and researchers hoping to come up with precision treatments for the deadliest, most aggressive cancers. For instance, glioblastoma, the brain cancer, has the lowest median survival time from diagnosis—15 months—of any major cancer. It's challenging enough to design a drug that can make it through the blood-brain barrier to get at a glioblastoma tumor. The disease works so quickly that there's barely time to give an experimental drug a chance to show whether or not it is effective.

To give more experimental precision drugs a better shot at glioblastomas, the newly created Ivy Brain Tumor Center at the Barrow Neurological Institute in Phoenix has developed "accelerated trials" for its brain-cancer patients. A newly diagnosed patient is first given a dose of an experimental precision drug. The dose is too small to harm the patient (in case it turns out to be toxic, always a risk with new drugs) but big enough to reach the tumor. After surgery, doctors test the tumor to see if the drug had any effect. If it did, the patient continues with an increased dose. If not, the patient and doctor find out in time to take another course of treatment. "Speed is the key to finding drugs that work," says Ivy director Nader Sanai. The approach has already turned up a personalized treatment that in one patient's case beat back a form of brain cancer called malignant meningioma.

While all these approaches together are likely to bring us closer to the day when most cancers succumb to precision treatments, no one thinks that day will be here soon. Still, the move to personalized treatments is benefitting almost all cancer patients by sparing them the ordeal of a treatment that has little chance of working. "If you can look at a genomic or other test and know ahead of time whether or not a patient's tumor will respond to a treatment, then even if only one out of 100 patients responds you've saved 99 patients from unnecessary complications and expense," says Stanley Robboy, vice-chair for diagnostic pathology at the Duke University Cancer Center. "These drugs can cost $100,000, and can bankrupt families."

Even that modest benefit, however, is being denied to most advanced cancer patients today. Health insurance companies frequently balk at paying for the genetic tests, which can cost as much as $10,000. "Medicare and some companies are starting to provide some coverage," says Roychowdhury. "But it's an arduous process to get reimbursed for the testing, and it's hard to get the cutting-edge tests covered at all." That's one reason most of the top cancer centers in the country don't routinely provide the testing to all their

Computers can TEASE OUT PATTERNS in the data that a human could never see.

BSIP/UNIVERSAL IMAGES GROUP/GETTY

PARTIAL PROGRESS
The outlook has improved for some cancers once considered virtual death sentences. About half of lung cancer patients respond well to targeted therapy. Precision medicine has also shown good results in treating breast cancer.

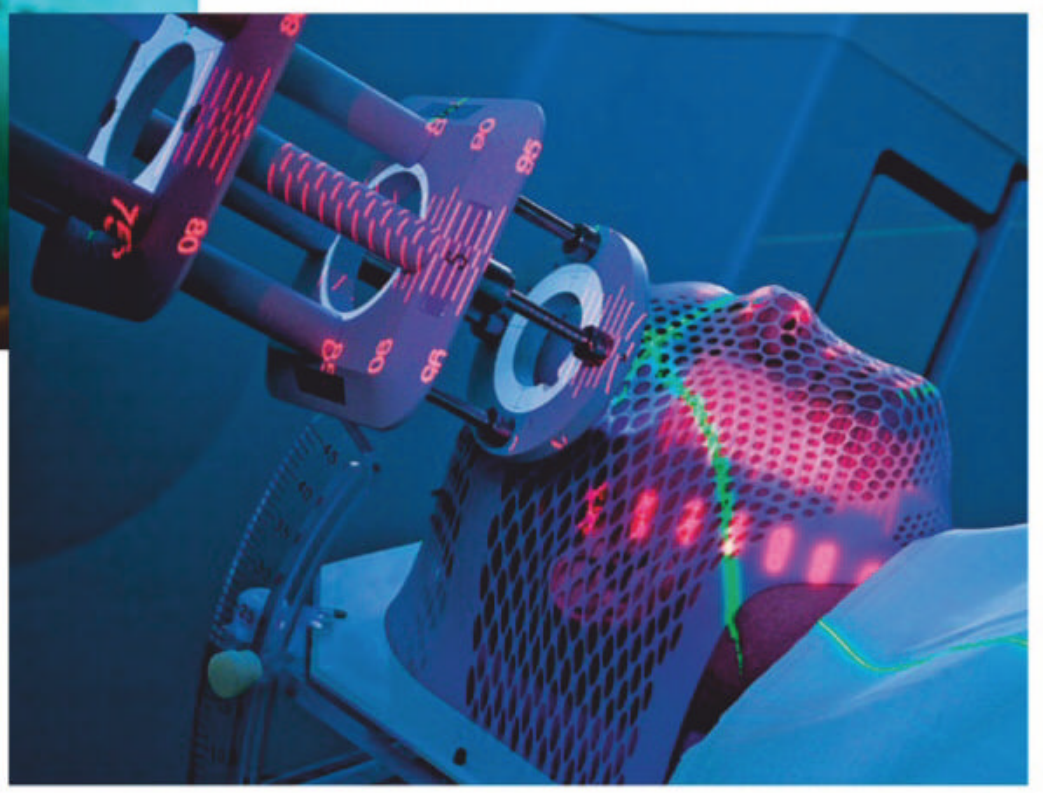
patients, even though virtually all experts agree that should be the standard of care everywhere for cancer.

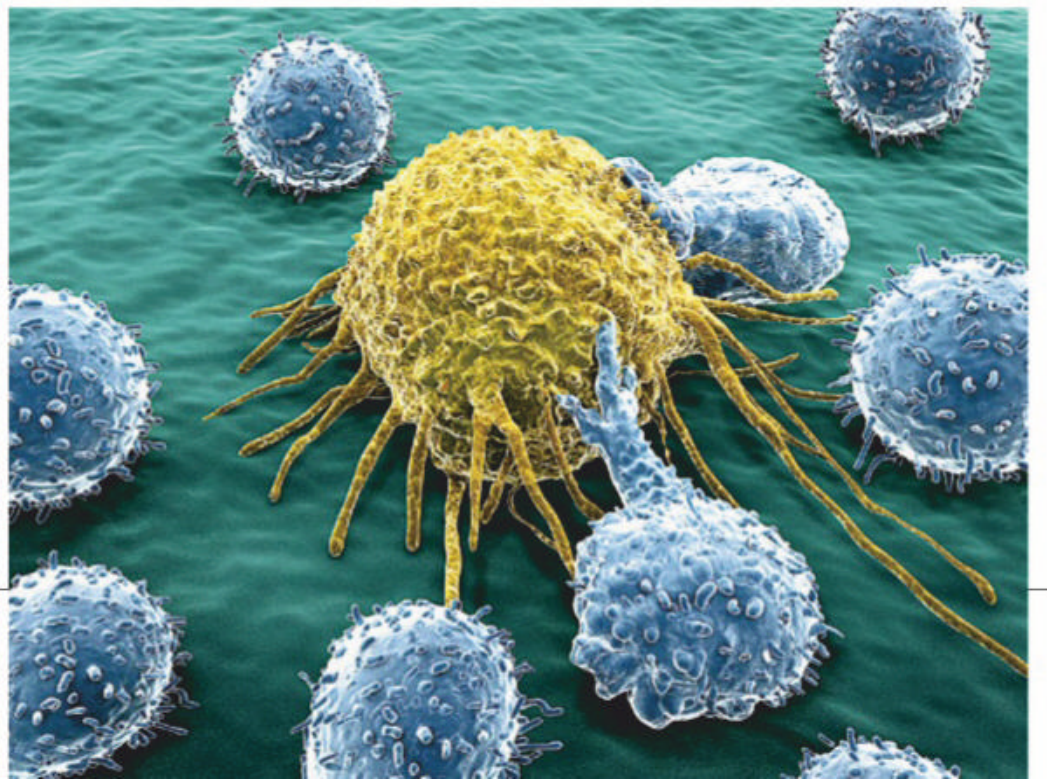
When a patient does get a tumor tested and the test shows a match to a promising precision drug, insurers often refuse to pay for the drug too, says Roychowdhury. The insurers cover only drugs that have already gotten FDA approval as a standard treatment, after a long period of trials. FGFR inhibitors of the sort that rescued Linda Boyed and many others are still usually not reimbursable. Patients who become part of formal drug trial, as Boyed did, usually get the drug for free. But in some cases patients with the most advanced cancers—the ones who need experimental drugs the most—are excluded from trials. Drug companies and even academic researchers often want to avoid including very sick patients out of fear they'll skew the results toward failure.

Payment isn't the only obstacle to treatment. About 85 percent of U.S. cancer patients get treated at a community hospital, where they see an oncologist who treats many different types of cancers. Those generalists are typically not up on the latest tests and treatments, says Caligiuri. The hospitals who employ them don't expect them to go through the time and expense of figuring it out. While highly regarded cancer centers place as many as a quarter of their patients on newer precision drugs, the percentage at most community hospitals is nearly zero.

What should patients do? "The first and most important thing I would say to anyone who has just received a diagnosis of cancer is that you need to get a second opinion from an oncologist who is a specialist in your type of cancer before you start any treatment," says Caligiuri. "If your first treatment isn't the optimal one, the tumor develops multiple resistances not only to that treatment but to other treatments that might have worked if you got them first." When asked about other treatment options, community oncologists often insist that patients are best off starting treatment first. Some play on patients' fears

QUICK OFF THE MARK
Speed is the key to finding drugs that work against brain cancer. To develop precision drugs against gioblastomas, one of the quickest and deadliest cancers, the Ivy Brain Tumor Center at the Barrow Neurological Institute in Phoenix has started accelerated trials Clockwise from top: Dr. Nader Sanai at Ivy; radiation therapy is a common treatment for brain cancer; immune system cells attack a migrating cancer cell.





CLOCKWISE FROM LEFT: COURTESY OF IVY BRAIN TUMOR CENTER; MARK KOSTICH/GETTY; SELVANEGRA/GETTY

> If everyone routinely got GENETIC SCREENING to see which cancers they're at risk for, tests like PET scans, which are expensive, could be given selectively. The right image every three years can change your life.

that even a short delay might hurt their chances of recovery—when in fact, it might save their lives.

Vanderbilt's cancer center is trying to fix this problem by boosting the participation of community-hospital oncologists in precision-medicine initiatives. Its My Cancer Genome website helps doctors and patients find out what new treatments and trials might be available for any particular cancer—the site lists 4,000 trials. "It pains me when patients come to us and they've already been given a treatment that wasn't going to help them," says Vanderbilt's Balser. "At that point the patient is behind the eight ball, and all we can do is try to pick up the pieces." Like many other top cancer centers, Vanderbilt is also creating affiliations with community hospitals in its region to support those hospitals in gaining access to precision-medicine expertise, genetic testing and trials of the newest drugs. Vanderbilt already has forged such ties to nearly 70 hospitals in five states.

A growing roster of precision-medicine approaches will also help in preventing cancers from taking hold in the first place. Some imaging techniques, such as PET scans, are approaching the needed sensitivity and resolution to pick up a cluster of newly formed cancer cells so tiny that it can be blasted away on the spot with a beam of focused radiation. Such treatments would be convenient and come with fewer complications.

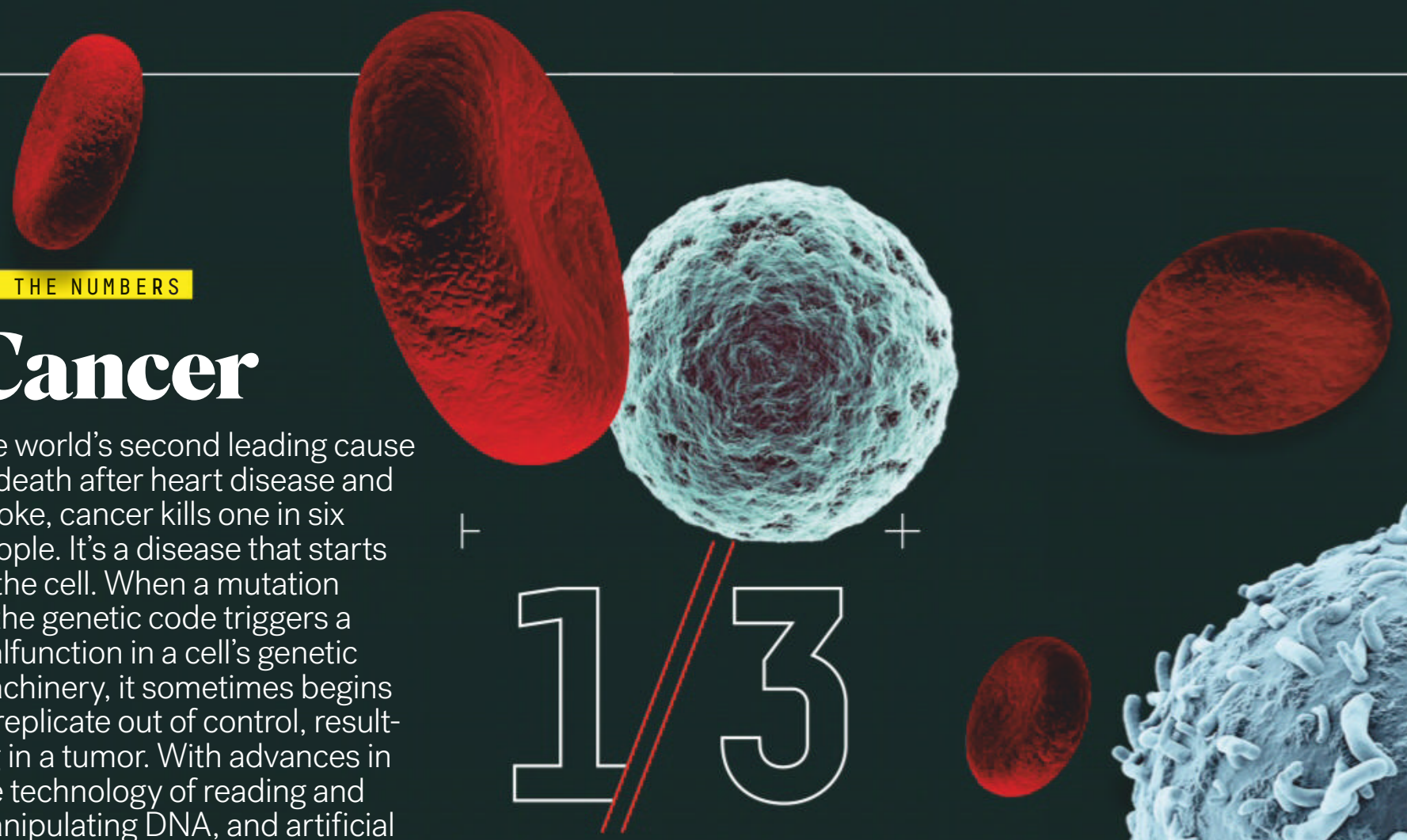
And why wait until someone gets cancer to look at genetic information? If everyone routinely got genetic screening to see which cancers they're at high risk for, tests like PET scans, which can cost $7,000 or more, could be given selectively. Unfortunately, genetic screening itself is currently either too expensive or, in the case of consumer-focused genetic-testing companies like 23andMe, too unrefined to justify being rolled out to the entire population. But researchers and biotech companies are working on cutting the costs and raising the accuracy of genetic tests. "If we can know the cancer you're at risk for, the right image every three years can change your life," says Caligiuri.

Of course, it would be good to know that if a cancer does slip through, precision medicine will have just the right drug for it. That way cancer patients will have more to look forward to than just being made comfortable in their final days—the fate that was Linda Boyed's, until it wasn't. N

BY THE NUMBERS

Cancer

The world's second leading cause of death after heart disease and stroke, cancer kills one in six people. It's a disease that starts at the cell. When a mutation in the genetic code triggers a malfunction in a cell's genetic machinery, it sometimes begins to replicate out of control, resulting in a tumor. With advances in the technology of reading and manipulating DNA, and artificial intelligence to help interpret genetic information, scientists have developed ways of predicting what drugs will work best on which cancers, known as precision medicine. *—Noah Miller*



1/3

The proportion of people in the U.S. who will develop cancer in their lifetimes. Today, more than 15 million Americans have had some type of cancer[1]

96,000,000,000,00

Each year, about 650,000 cancer patients receive chemotherapy in an outpatient oncology clinic in the United States. 75% of cancer patients receiving chemotherapy that experience mental impairments during treatment; for some patients, these problems persist for years afterwards.[3]

ONE IN EIGHT

Number of women in the U.S. who will be diagnosed with breast cancer in their lifetime.[4]

15 PERCENT

The proportion of cancer patients who had genomic testing and ended up receiving a targeted therapy.[5]

SIXTY-SIX

Median age of patients who receive a cancer diagnosis.[6]

1 AMERICAN CANCER SOCIETY 2 MD ANDERSON CANCER CENTER 3 CENTERS FOR DISEASE CONTROL AND PREVENTION 4 NATIONAL CANCER INSTITUTE 5 JAMA 6 WORLD HEALTH ORGANIZATION
7 NATIONAL CANCER INSTITUTE 8 THE AMERICAN JOURNAL OF MEDICINE 9 SOURCE: AMERICAN CANCER SOCIETY 10 HEALTH AFFAIRS 11 AGENCY FOR HEALTHCARE RESEARCH AND QUALITY

$2.5 BILLION

Estimated cost to Medicare of genomic testing for people with advanced cancers, after a decision last year to cover them[10]

42% → Percentage of cancer patients who went broke within two years of being diagnosed. Average loss: $92,000.[8]

70% The proportion of deaths from cancer that occurs in low- and middle-income countries.[7]

10,590

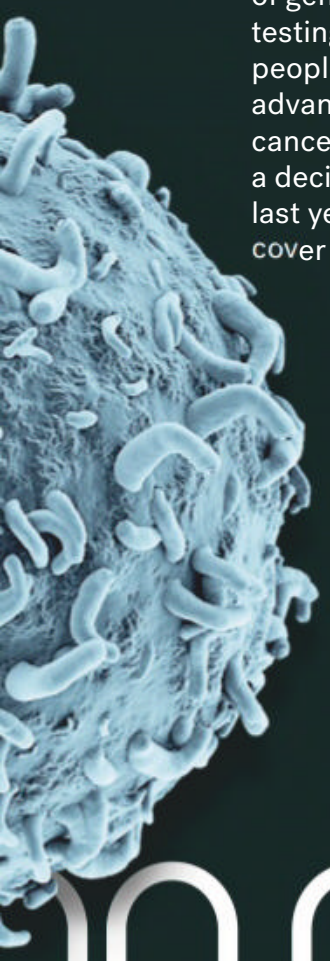
Number of children aged 1 to 14 who were diagnosed with cancer in the U.S. in 2018[9]

29%

The percentage of children with cancer who have leukemia, the most common form of cancer in the U.S. for people under age 15

26%

The percentage of children with cancer in the U.S. who are diagnosed, respectively, with either cancer of the brain or the nervous system



3,000,000,000

The number of DNA nucleotides, or bits of information, in all the cells of a typical human body; each of them is subject to mutation[2]

$80.2 billion

Total healthcare expenditures for cancer in the U.S. in 2015, including both outpatient and hospital treatment and services.[11]

NEWANNYART/GETTY; CONEYL JAY/GETTY

Photo illustration by GLUEKIT

MCADVOCATE
Gretchen Carlson's expose about sexism at the fast food chain. » P.48

GETTY (1); TOP RIGHT: JAMIE MCCARTHY/GETTY

MUSIC

Happy 50th Woodstock!

We watched the movie so you don't have to

WOODSTOCK, AS YOU MAY HAVE ALREADY HEARD TO AN EXCESSIVE DEGREE by now, defined in some ways the entire baby boom generation. You know, three days of peace, love and understanding and all that jazz.

The truth is this: There were some 400,000 people who actually attended the event over three days in August 1969. But most of us experienced it through the documentary—and the soundtrack—that came out about six months after the event.

The music was all-in-all pretty great, and a lot of acts from Joe Cocker to The Who to Sly and the Family Stone to Santana and, of course, Jimi Hendrix, had star turns.

The documentary itself? If you're as jaded and cynical as we are, the answer is "meh"; better at the time, in other words. There's only so much you can take of watching people rolling around in the mud and traffic jams—and announcements about staying away from the brown acid. And while some bad performances were mercifully left on the cutting room floor, so were a few great ones. To find some acts that were unjustly left out of the original version of the film and album (and some that should have been left out), we sat through the recently re-released director's cut and scoured the Internet. Here's what we came up with.

BY

PETER CARBONARA & HANK GILMAN

ACTS THAT SHOULD HAVE MADE IT BIG BUT DIDN'T

Sweetwater
Not in the movie. They followed an iconic Richie Havens performance. As luck would have it, they were scheduled to go on first, but got stuck in traffic. Interesting band, though: a mixed-race group with multiple singers, including female vocalist Nancy Nevins wearing an un-Woodstock-like pink dress. They were brave souls for sure: Who starts a set with a cello/noise solo? Answer: a band with a lead singer wearing a long pink dress. "Thank you very much," Nevins told the audience at the end of their set. "There sure are a lot of people here. I hope this festival turns out real nice." She was badly injured not long after in an auto accident and the band stalled. YouTube diving: You can find the band performing, in good form, on *Hugh Hefner's Playboy After Dark* television show.

Bert Sommer
Probably The Great Lost Performance of Woodstock. This

guy seemed to have everything he needed to become a star: Good looks and voice, charisma. He was a nimbus of frizzy hair—and an original cast member of *Hair*. The band had two electric guitars, organ and hippy love-songs. Sommer's raga-ish song "Jennifer" won the crowd. (He kind of sounded like Tim Buckley if you know what Tim Buckley sounded like.) Supposedly got the only standing ovation of the festival, but you can't see that in clips on YouTube. Rumor mill: Slated for big things, but allegedly left out of the film and album because he was signed to Capitol records and the soundtrack was bankrolled by Atlantic Records' Cotillion.

JUSTLY FORGOTTEN

Quill

Primarily a northeast U.S. touring band, Quill was known to have a loyal following and also got gigs opening for the likes of the Kinks, Deep Purple and Jeff Beck. Not in the movie.

Keef Hartley Band

Drummer Keith "Keef" Hartley led a horn-based band that was kind of like Chicago. Weird fact: Hartley replaced Ringo in Rory Storm and the Hurricanes. Not in the movie.

OVERLOOKED STAR TURNS

Ravi Shankar

Should have been in the movie. The sitarist was intense and joyful as always doing an evening raga with tabla-ist Alla Rakha. Amazing musical back and forth between them at high speed. Two master musicians in front of a group of stoned kids, giving 100%. Our take: This is what pros look like.

Melanie

Like Bert Sommer, Melanie Safka was a relative unknown who had a big moment at Woodstock, but was not in the movie. She took the slot originally for the English folk group, Incredible String Band who wouldn't play in the rain. The crowd loved her, and she went on to write great songs like the hit "Brand New Key" so it didn't matter one bit that she was left on the cutting room floor. So there. Melanie extra: She had another hit with "Lay Down (Candles in the Rain)," which, the story goes, was based on her experience at Woodstock.

WHOLE LOTTA SHAKIN' GOIN' ON Attendance figures for what was billed as "three days of peace and music" have always been something of a guess as people without tickets quickly overwhelmed the site, but the current consensus number is about 400,000. Among the festival's biggest stars were Roger Daltrey (above) of The Who, who performed their rock opera *Tommy*, and Sly Stone (right) whose band's rapturous blend of funk and pop was arguably the highlight of the entire event.

CLOCKWISE FROM TOP LEFT: RB/REDFERNS/GETTY; CLAYTON CALL/REDFERNS/GETTY; BLANK ARCHIVES/GETTY; MICHAEL OCHS ARCHIVES/GETTY

Some bad performances were left on the cutting room floor. So were a few great ones.

WE WISH THESE OTHER ACTS WERE IN THE DIRECTOR'S CUT

Mountain
The heavy blues-rock band that prefigured so much '70s sludge featured star guitarist Leslie West. They're known for the hit "Mississippi Queen," but the gem of their Woodstock set was their performance of "Theme From an Imaginary Western." Inside baseball: The song was written by Cream legend Jack Bruce—and sung by Mountain's bass player Felix Pappalardi, who had also produced Cream.

Creedence Clearwater Revival
Not in the movie nor the original record, though they were a very hot band at the time. Their blue-collar sensibility and lack of psychedelic pretension always set them apart from the rest of the San Francisco crew. Famous observation: Lead singer/songwriter John Fogerty said the Grateful Dead who preceded them put the crowd to sleep and he had to try to wake them up.

NOT MISSED

The Grateful Dead
Not in the movie. They just looked and sounded tired. A sluggish "Mama Tried" and listless "Turn on Your Love" light. See: Creedence Clearwater Revival above.

WHAT WAS WITH NEIL YOUNG AND CSN&Y?

Crosby, Stills, Nash & Young
Only their second live performance as a group. Neil Young refused to be filmed because he has said the cameras were a distraction to the fans and the band. Bottom line: It didn't matter; they were already rock stars, and they went on to become mega-rock stars.

MUST-SEE PERFORMANCES

The Who
Doing their standard set of the time which consisted of *Tommy* in its entirety, which even for fans could be a chore to sit through. Made worth it though by their performance of "Pinball Wizard" and especially the instrumental "Sparks" (not in the movie) with its incredible dynamics, growing in volume and tension until it blows up in a wave of incandescent noise. Bonus points for guitarist Pete Townsend's pointed response to Abbie Hoffman's attempt to commandeer the microphone "F...off my f... ing stage!"

Jimi Hendrix
The "Star Spangled Banner" is justly legendary, but Hendrix had the bad fortune to go on after most people had left. The crowd responded to the hits played loud, but didn't seem to get his new funk and jazz-inflected material. Highlight: "Purple Haze" and the kissing the sky thing.

Sly and the Family Stone
Sly Stone may have stolen the entire show performing songs from, among other things, his studio album *Stand!* A religious experience. The great Larry Graham on bass and Cynthia Robinson—and all that hair—on trumpet and vocals. Good lord!

Joe Cocker and the Grease Band
The signature song was Cocker's dynamic performance of "With a Little Help From My Friends." Cocker's performance was raw power. Great falsetto vocals by his backing band, too. Imagine if they had Auto-Tune back then.

Santana
'Soul Sacrifice" still sounds great today along with its awesome drum solo by 20-year-old Michael Shrieve. Fun fact: Keyboard player and singer Gregg Rolie has been inducted into the Rock & Roll Hall of Fame with two bands: Santana and Journey.

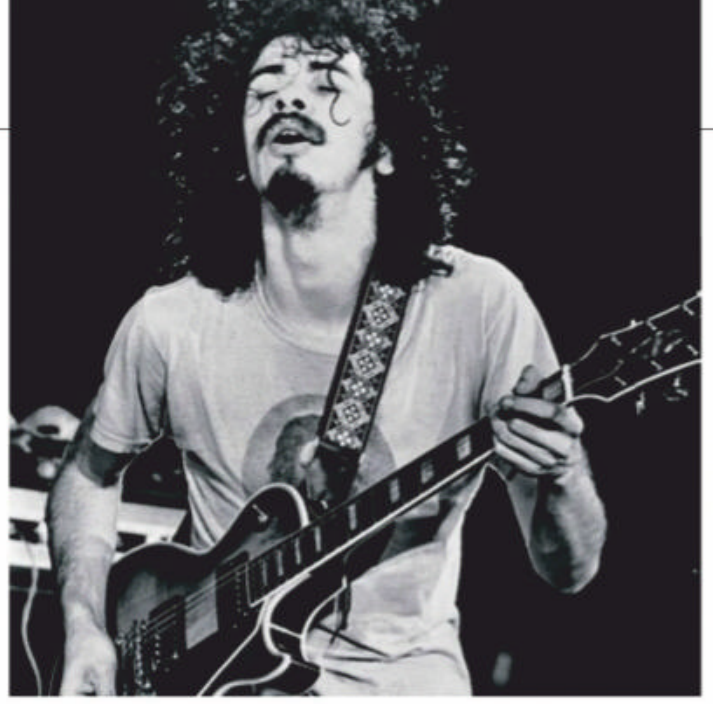
STILL ON TOUR 50 YEARS LATER

A Sampler
The Who; Hot Tuna (a Jefferson Airplane spin-off); Joan Baez; Melanie; John Sebastian; Carlos Santana; Country Joe McDonald; John Fogerty; and in various configurations, Crosby, Stills, Nash & Young.

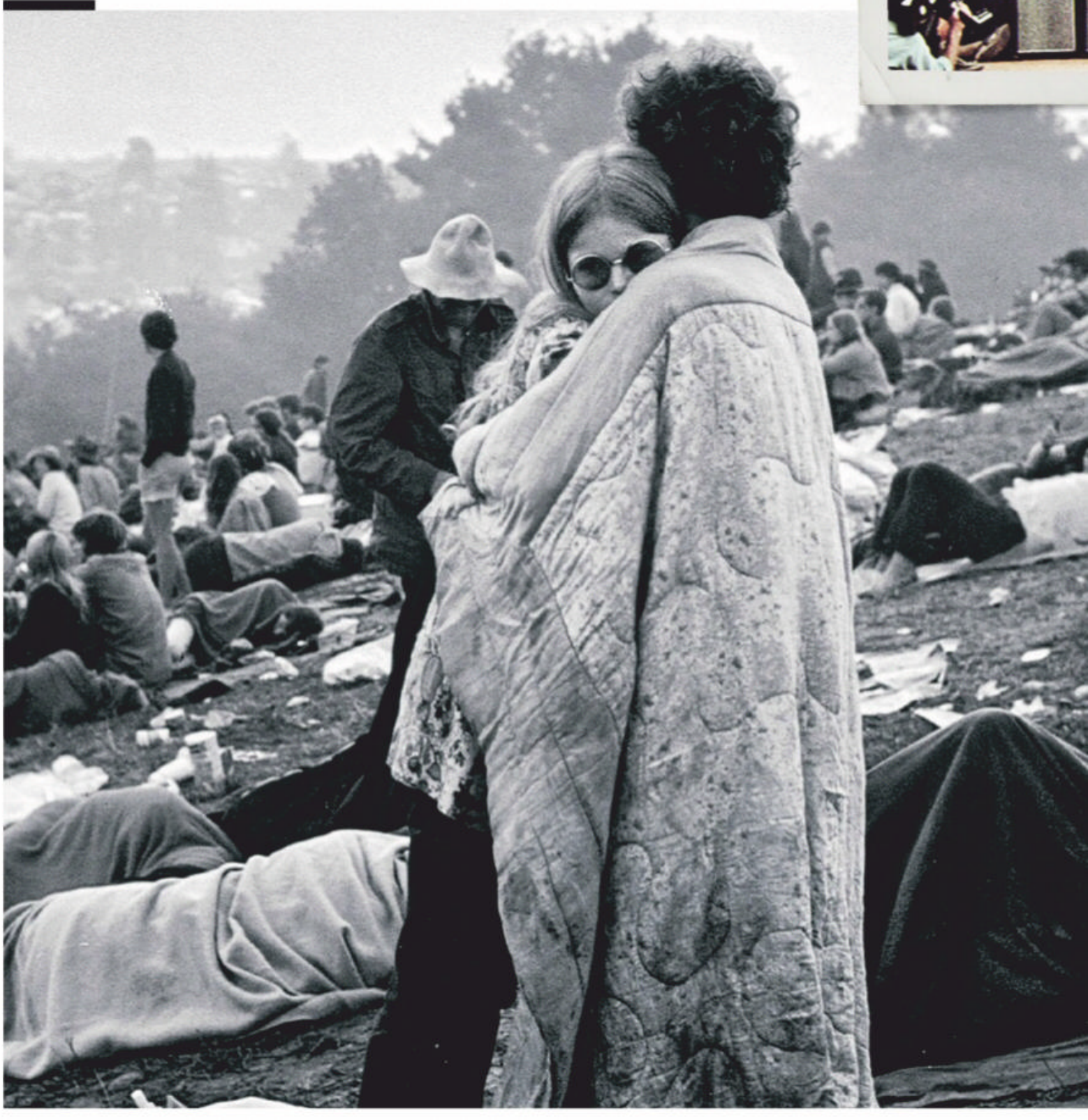
50TH ANNIVERSARY CONCERT UPDATE

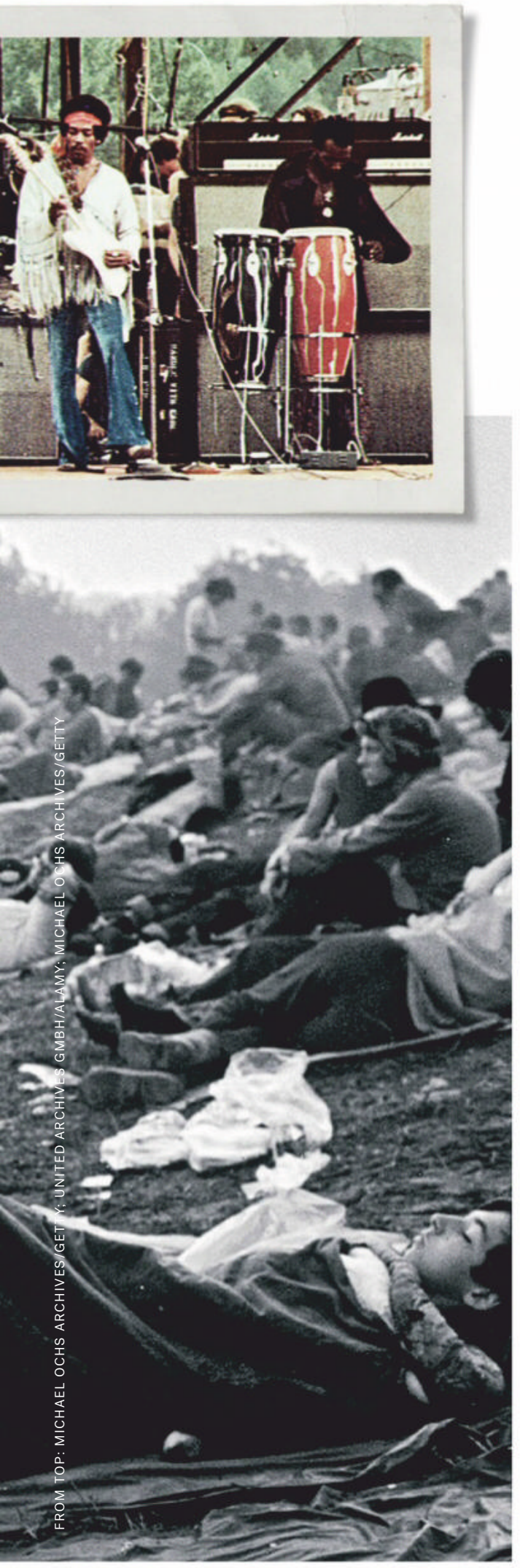
As we write, a venue has not been secured in upstate New York. N

There's only so much you can take of people rolling around in mud and warnings about the brown acid.



GUITAR HEROES His performance at Woodstock made Carlos Santana (above) a star. Well-established Jimi Hendrix, meanwhile, used the festival to showcase a new band.

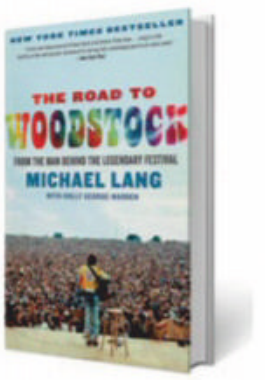




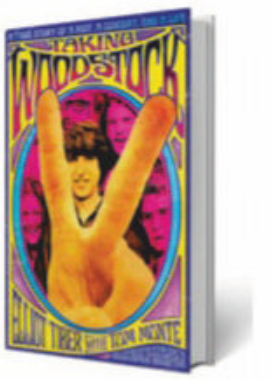
FROM TOP: MICHAEL OCHS ARCHIVES/GETTY; UNITED ARCHIVES GMBH/ALAMY; MICHAEL OCHS ARCHIVES/GETTY

Woodstock in Words, Music & Film

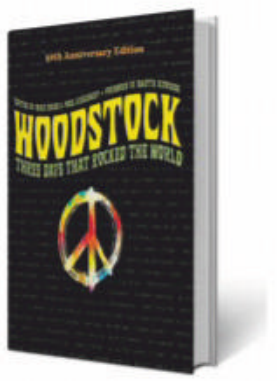
Back To The Garden: The Story of Woodstock
Pete Fornatale
TOUCHSTONE/SIMON & SCHUSTER, $24.99



The Road to Woodstock
Michael Lang with Holly George-Warren
ECCO/HARPERCOLLINS PUBLISHERS, $29.99

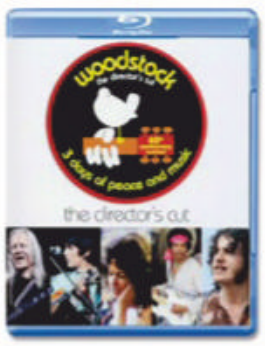


Taking Woodstock: A True Story of a Riot, a Concert, and a Life
Elliot Tiber with Tom Monte
SQUAREONE, $24.99

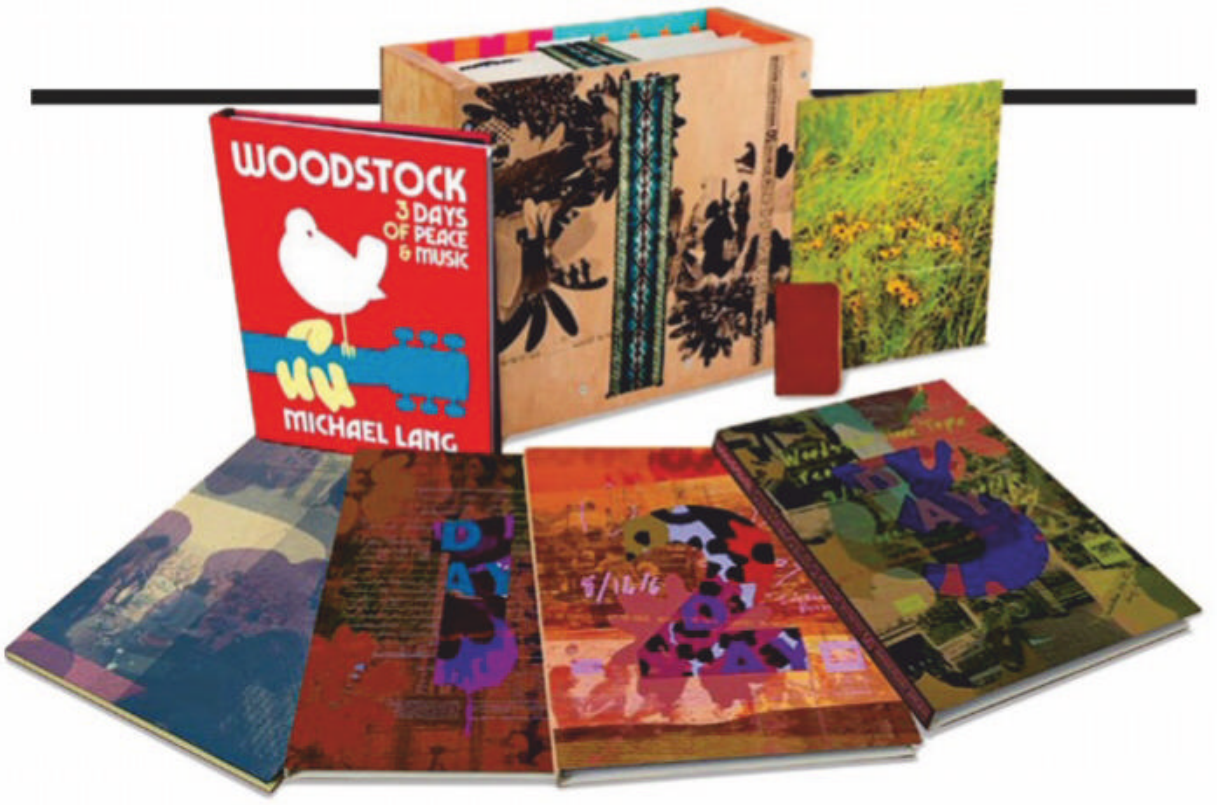


Woodstock: 50th Anniversary Edition: Three Days That Rocked The World
Mike Evans (Ed.), Paul Kingsbury (Ed.), Martin Scorsese (Foreword)
STERLING, $14.99

Woodstock: Back To The Garden: 50th Anniversary Experience
10 CDs. A smaller bite, songs from everyone who performed
RHINO, $159.98

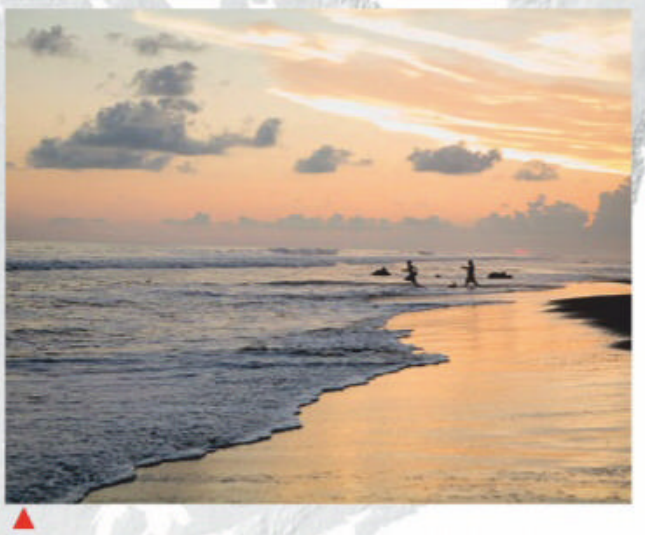


Woodstock (Director's Cut Blu-Ray)
Various cuts of the movie also available on numerous streaming services
$15 VIA AMAZON PRIME



Woodstock: Back To The Garden: The Definitive 50th Anniversary Archive
38 CDs. Not absolutely every note played, but pretty close, plus numerous extras. RHINO, $799.98

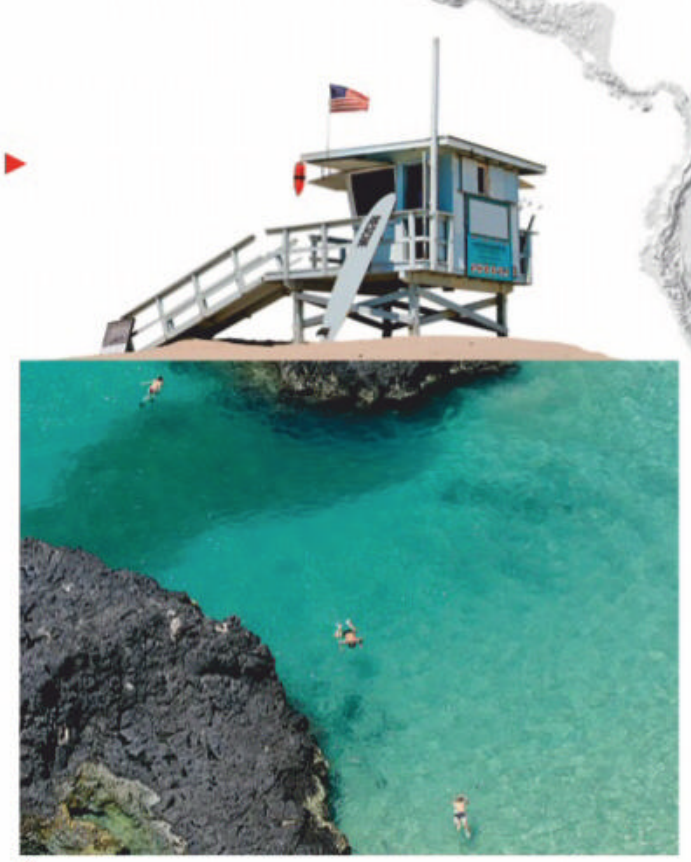
01 Hanalei Bay, Hawaii
This picture-perfect beach town on Kauai is magical. With waterfalls behind you and beautifully tubed waves in front of you, it's a beach that pro and amateur surfers alike love.



03 Troncones, Guerrero, Mexico
Decent waves of all sizes can be found year round on the beaches of this former fishing village, now surf hotspot. For beginners, there's the placid surf at Playa Troncones and for people who want a challenge, there are the large, crashing waves at Troncones Point.

06 Carrapateira, Portugal
Unlike its more famous and violent sister—The Praia do Norte in Nazaré, with waves that get up to 80 feet high—the beaches in Carrapateira have manageable waves and are usually empty.

02 Malibu, California
It's easy to forget that Malibu started out not as the home to the rich and famous, but as a small surfing community. The Surfrider Beach is still universally popular as locals and tourists alike ride the relatively calm waves below the Malibu cliffs.



04 Fernando de Noronha Island, Brazil
This small island in the north of Brazil has huge swells and reef breaks up to 15 feet high. Bonus: it's clean, unlike some of the other more famous beaches in Brazil. Double bonus: it has amazing scuba diving.

05 Muizenberg, South Africa
Considered to be the birthplace of surf culture in South Africa, this suburb of Cape Town is home to beautiful breaks—and shark spotters, who watch for Great White sharks from the cliffs above.

01: BJONESMEDIA/GETTY; 02: FRANKVANDENBERGH/GETTY; 03: PAPHOTO/ALAMY; 04: SAMBAPHOTO/LEONARDO PAPINI/GETTY; 05: SHAUN/GETTY; 06: MAURICIO ABREU/GETTY; 07: CHRISTIAN ASLUND/GETTY; 08: SALLY DILLON/GETTY; 09: SILVRSHOOTR/GETTY; 10: MANFRED GOTTSCHALK/GETTY

07 Killer Point, Taghazout, Morocco
Just north of Agadir lies the small fishing village of Taghazout, which has been home to surfers since the 1960s. Killer Point, named for the killer whales in the area, is the place to go for perfect, powerful breaks.

09 Shikoku Island, Japan
The smallest of Japan's major islands, Shikoku is home to an 88-temple Buddhist pilgrimage route, feudal Matsuyama Castle and great surf. To avoid freezing, however, hit up the swells on the southeast coastline during preak season which runs between June and November.

10 Byron Bay, New South Wales, Australia
One of the most iconic surf spots in the world, the ultra-chill town of Byron Bay has it all—warm water, ready waves and even some shipwrecks in the area for diving. But be alert: While nets have been implemented, a shark still slipped through in February and bit a man.

08 Cloud 9, Siargao Island, Philippines
Cloud 9 is the name of the most famous wave that haunts this island. While the locals offer lessons, the power of the waves -- and the razor-sharp coral-- make the surfing here too challenging for the inexperienced.

UNCHARTED

The World's Best Surf Spots

Almost nothing embodies freedom, fun and utter cool like surfing. The sport may have started in Hawaii and the South Pacific in the 1800s, but it was brought to the mainland U.S. after Jack London heard about it and sang its praises in a 1907 magazine article. In the 1960s, surfing went mainstream with some help from bands the Beach Boys and it can now be found worldwide. Wherever there is a reef, a break or a wave, there is almost certainly someone on a board. —*Paula Froelich*

Illustration by BRITT SPENCER

PARTING SHOT

Gretchen Carlson

FORMER FOX NEWS ANCHOR GRETCHEN CARLSON WANTS WOMEN (and men) to feel safe at work. The women's empowerment advocate helped lead the way for the #MeToo movement when she filed a sexual harassment lawsuit against Fox chairman Roger Ailes in 2016. Not only did Ailes eventually step down as CEO, but the network settled the lawsuit for $20 million and publicly apologized to Carlson. After writing her best-selling novel *Be Fierce,* Carlson was inspired to work with Lifetime on the documentary *Breaking the Silence,* which uncovers the stories of McDonald's workers who allegedly experienced sexual harassment and abuse in the workplace. Now, Carlson's own personal journey is being turned into a movie, starring Nicole Kidman, as well as a Showtime series starring Naomi Watts. "My hope is that they stop turning a blind eye to sexual harassment and determine how to make workplaces safer for everyone," Carlson says. "It's not that tough. The final part in really making change is having companies realize this is not a passing fad."

"The final part in really making change is having companies realize this is not a passing fad."

What is it like to have Kidman and Watts portray you on film and TV?
It's surreal to have these two best friends in real life playing me—a small-town girl from Minnesota.

Why did you focus on McDonald's?
The stories were compelling and nobody had told it before. People are scared of really getting down to the nitty gritty. The only way companies are going to fix the problem is if we actually talk about it and force change.

How did you get the women in the documentary to open up to you?
We immediately had a connection. They knew that I wasn't going to judge them. They knew I understood them. They also knew that I was going to go and try and get answers for them.

Were you surprised by anything in this documentary?
I got to see the transformation of these young women from immense pain to being leaders. It's an amazing story about hardship. It's emblematic to my life in a way. They are now speaking their truths and being a voice to empower other women. They actually become more whole as people from their experience. I didn't know I was going to capture that. Sometimes people don't want to talk about this issue because they think it's sad and it's just easier to ignore it, but what's great is that you see this positive outcome. They're amazing examples now for their children and for other families. —*Maria Vultaggio*

Tinalbarka wants to be a lawyer.
She and her family fled violence in Mali.

We stand together
#WithRefugees

PHOTO: © UNHCR / A. DRAGAJ

worldrefugeeday
www.refugeeday.org

UNHCR
The UN Refugee Agency